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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

UTILITY APPLICATION AND APPLICATION FEE TRANSMITTAL (1.53(b))

ASSISTANT COMMISSIONER FOR PATENTS
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Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of

Named Inventor(s) and
Address(es): Seiya OHTA, 7-13, Daimachi, Kanagawa-ku, Yokohama-shi, Kanagawa-ken, Japan.

For: OPTICAL EQUIPMENT AND ITS CONTROL METHOD, AND COMPUTER
 READABLE STORAGE MEDIUM

Enclosed are:

☒ 65 page(s) of specification, 1 page(s) of Abstract, 22 page(s) of claims

☒ 31 sheets of drawing ☒ formal ☐ informal

☒ 6 Page(s) of Declaration and Power of Attorney

☐ Unsigned

☒ Newly Executed

☐ Copy from prior application

☐ Deletion of inventors including Signed Statement under 37 C.F.R. § 1.63(d)(2)

☐ Incorporation by Reference: The entire disclosure of the prior application, from which a copy of the combined declaration and power of attorney is supplied herein, is considered as being part of the disclosure of the accompanying application and is incorporated herein by reference.

☐ Microfiche Computer Program (Appendix)

☐ _____ page(s) of Sequence Listing

☐ computer readable disk containing Sequence Listing

☐ Statement under 37 C.F.R. § 1.821(f) that computer and paper copies of the Sequence Listing are the same

☒ Claim for Priority Japanese Patent Application Nos 9-350965 filed 12/19/97; 9-350966 filed 12/19/97; 9-364757 filed 12/22/98 and 9-364759 filed 12/22/98

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- ☐ Certified copy of Priority Document(s)
- ☐ English translation documents
- ☐ Information Disclosure Statement
- ☐ Copy of __cited references w/ English Abstracts
- ☐ Copy of PTO-1449 filed in parent application serial No._____.
- ☐ Preliminary Amendment
- ☒ Return receipt postcard (MPEP 503)
- ☒ Assignment Papers (assignment cover sheet and assignment documents)
- ☒ A check in the amount of \$40.00 for recording the Assignment.
- ☐ Assignment papers filed in parent application Serial No. _____.
- ☐ Certification of chain of title pursuant to 37 C.F.R. § 3.73(b).
- ☐ This is a ☐ continuation ☐ divisional ☐ continuation-in-part (C-I-P) of prior application serial no. _____.
- ☐ Cancel in this application original claims _____ of the parent application before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ A preliminary Amendment is enclosed. (Claims added by this Amendment have been properly numbered consecutively beginning with the number following the highest numbered original claim in the prior application.
- ☐ The status of the parent application is as follows:
- ☐ A Petition For Extension of Time and a Fee therefor has been or is being filed in the parent application to extend the term for action in the parent application until _____.
- ☐ A copy of the Petition for Extension of Time in the co-pending parent application is attached.
- ☐ No Petition For Extension of Time and Fee therefor are necessary in the co-pending parent application.
- ☐ Please abandon the parent application at a time while the parent application is pending or at a time when the petition for extension of time in that application is granted and while this application is pending has been granted a filing date, so as to make this application co-pending.
- ☐ Transfer the drawing(s) from the patent application to this application.
- ☐ Amend the specification by inserting before the first line the sentence:
This is a ☐ continuation ☐ divisional ☐ continuation-in-part of co-pending application Serial No. _____ filed _____.

I. CALCULATION OF APPLICATION FEE (For Other Than A Small Entity)

	Number Filed		Number Extra	Rate	Basic Fee
Total Claims	75	-20=	55	x\$18.00	\$ 760.00
Independent Claims	19	- 3=	16	x78.00	\$1,248.00
Multiple Dependent Claims					
	[] yes		Additional Fee =	\$260.00	\$
	[] no		Add'l Fee =	NONE	

Total: \$2,998.00

- [] A statement claiming small entity status is attached or has been filed in the above-identified parent application and its benefit under 37 C.F.R. § 1.28(a) is hereby claimed. Reduced fees under 37 C.F.R. § 1.9(F) (50% of total) paid herewith \$ _____.
- [X] A check in the amount of \$ 2,998.00 for payment of the application filing fees is attached.
- [] Charge Fee(s) to Deposit Account No. 13-4500. Order No. _____. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.
- [X] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required for filing this application, or credit any overpayment to Deposit Account No. 13-4500, Order No. 1232-4494. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

Respectfully submitted,

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By: 

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Registration No 32,537Dated: December 14, 1998

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : Seiya OHTA
Serial No. : TBA Group Art Unit : TBA
Filed : December 14, 1998 (Herewith)
For : OPTICAL EQUIPMENT AND ITS CONTROL METHOD, AND COMPUTER-
READABLE STORAGE MEDIUM

EXPRESS MAIL CERTIFICATE

Express Mail Label No. EE645139403US

Date of Deposit December 14, 1998

I hereby certify that the following attached paper(s) and/or fee
Application Fee Transmittal; 65 pp. of specs., 22 pp. claims (75 TOTAL claims); Check in the amount of
\$2,998.00 (Filing Fee); 6 pg. Executed Declaration/POA; 31 Sheets of Formal Drawings (Figs. 1-31);
Assignment Recordation Form Cover Sheet w/1 pg. Executed Assignment; Check in the amount of \$40.00;
Certificate of Express Mail (Label No. EE645139403US) and Return Postcard

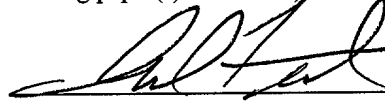
is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37

C.F.R. §1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Box New

Application, Washington, D.C. 20231.

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TITLE OF THE INVENTION
OPTICAL EQUIPMENT AND ITS CONTROL METHOD, AND
COMPUTER-READABLE STORAGE MEDIUM

5 BACKGROUND OF THE INVENTION

The present invention relates to an optical
equipment and, more particularly, to an optical
equipment such as a video camera, silver halide camera,
10 electronic still camera, or the like, which comprises an
optical system (photographing optical system) having a
movable lens group that moves along the optical axis
upon focusing or zooming, e.g., an optical system such
as a photographing lens of a single focal length, zoom
15 lens, or the like, its control method, and a storage
medium.

Conventionally, in case of a rear-focus zoom type
lens, the stop positions of a variator used in zooming
and a focus lens used in focus adjustment on the optical
20 axis change in units of object distances, as shown in
Fig. 1 (these curves will be referred to as "cam loci"
hereinafter). Referring to Fig. 1, for example, when the
object distance is infinity (or 2 m), the focus lens (RR
lens) moves on the optical axis along convex locus Y_{∞}
25 (or Y_2) toward the object side upon movement of the
variator from the wide-angle end to the telephoto end on

the optical axis.

That is, conventionally, upon zooming from the wide-angle end to the telephoto end or vice versa, when driving of the variator and focus lens is controlled to trace the cam locus in correspondence with the object distance, a good image free from any blur is obtained. That is, conventional cam trace is to merely track the stored cam locus.

However, an optical system and mechanical system normally suffer manufacturing errors, and it is difficult to match their movements with the theoretically obtained stored cam locus. It is also impractical to require of commercial products higher precision in the optical system and mechanical system to attain matching. In addition, with the conventional technique and camera precision, a given blur range cannot be visually recognized. However, as the image quality and magnification become higher in recent years or in the future, such blur range may be easily recognized.

Furthermore, it is important to attain high-precision cam trace with less labor and lower cost.

Also, in an exchangeable lens system that uses an exchangeable lens, an attachment having a zoom effect is normally interposed between lens and camera apparatuses (the attachment will be referred to as an extender

hereinafter). However, upon mounting the extender, the cam locus becomes considerably different from that without the extender.

Upon zooming, since the cam loci in units of object
 5 distances become denser toward the wide-angle position, as shown in Fig. 1, a cam locus corresponding to a given object distance cannot be accurately selected upon zooming from the wide-angle end to the telephoto end, and the initially selected cam locus may slightly
 10 deviate from that corresponding to the object distance.

In such case, blurring takes place upon zooming. For example, upon zooming from the wide-angle end to the telephoto end, when a cam locus corresponding to a non-in-focus object distance (e.g., 1 m) is selected and
 15 traced for an object at an object distance (e.g., 2 m) which does not correspond to the original in-focus locus, no blur (deterioration of the in-focus level) is not formed near the wide-angle end, but blur is produced from the middle focal length to the telephoto end. Also,
 20 when the object distance changes upon, e.g., movement of an object, an in-focus state cannot be attained by the cam locus traced so far, thus producing a blur.

In order to solve this problem, the following processing is done. That is, the in-focus level is
 25 checked by sampling an auto-focus signal (to be referred to as an AF signal hereinafter) at predetermined periods

from a video signal obtained from a photoelectric conversion element such as a CCD during zooming. The in-focus level obtained by the previous sampling is compared with that obtained by the current sampling to find a cam locus with higher in-focus level, and the cam locus is traced while changing the cam locus to that with higher in-focus level.

In this case, the AF signal is detected in synchronism with the vertical scanning frequency of the television format used in a video camera in case of the video camera. That is, the AF signal is sampled at a frequency of 50 Hz when the PAL format is used or at 60 Hz when the NTSC format is used. Note that one period will be expressed by 1V or V hereinafter.

As the image quality and magnification become higher, addition of a function that allows the photographer to take a broad range of pictures is required. Especially, demands for ultra-low-speed zooming, i.e., so-called "artistic zooming", and ultra-high-speed zooming for changing the field angle from the telephoto end to the wide-angle end or vice versa as quick as possible are very large.

However, when the zooming speed is varied over a broad range from ultra high speed to ultra low speed, in case of ultra-low-speed zooming, blur is produced in practice, but the in-focus level obtained by the current

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sampling remains the same as the previous value in
relation to the sampling period of an AF signal, and the
cam loci cannot be changed. As a result, the control
halts in a blur state. This problem occurs conspicuously
5 when a stepping motor is used to drive the variator or
focus lens, since such motor has a drive halt period.

Also, when the zooming speed is varied over a broad
range from ultra high speed to ultra low speed, if the
focus lens moving amount is corrected in consideration
10 of the in-focus level alone without taking the zooming
speed into consideration like in the conventional system,
the focus lens moving amount remains the same
irrespective of the zooming speed when the in-focus
level remains the same, thus posing the following
15 problem. For example, upon ultra-high-speed zooming, the
focus lens moves too much and overshoots the in-focus
cam locus to be selected, and blur stands out. By
contrast, upon ultra-low-speed zooming, a long time is
required until the in-focus cam locus is reached.

20

SUMMARY OF THE INVENTION

The present invention has been made in
consideration of the above-mentioned problems, and has
25 as its object to attain accurate cam trace with less
labor and lower cost.

It is another object of the present invention to reliably detect deterioration of the in-focus level irrespective of the zooming speed.

It is still another object of the present invention
5 to accurately and quickly correct the focus moving amount upon production of blur during zooming independently of the zooming speed.

In order to solve the above-mentioned problems and to achieve the above objects, an optical equipment
10 according to the present invention is characterized by the following arrangement.

That is, there is provided an optical equipment for forming an object image on a predetermined plane via an optical system including a movable lens that moves along
15 an optical axis, comprising lens drive means for driving the movable lens, first storage means for storing control information for controlling a position of the movable lens, second storage means for storing correction data for correcting the control data stored
20 in the first storage means, and control means for controlling the lens drive means on the basis of the control information in the first storage means and the correction data in the second storage means.

A storage medium according to the present invention
25 is characterized by the following arrangement.

That is, there is provided a computer-readable

storage medium storing a program for executing a
sequence for controlling driving of a movable lens using
control information for controlling a position of the
movable lens and correction data for correcting the
5 control information.

A storage medium according to the present invention
is characterized by the following arrangement.

That is, there is provided a computer-readable
storage medium storing difference information between
10 theoretical control information for controlling a
position of a movable lens, and true control information.

A lens apparatus according to the present invention
is characterized by the following arrangement.

That is, there is provided a lens apparatus
15 comprising movable lens means for forming an object
image on a predetermined plane while moving along an
optical axis, drive means for driving the movable lens
means, connection means for detachably attaching an
external device, detection means for detecting
20 attachment/detachment of the external device, first
storage means for storing first control information for
controlling a position of the movable lens means when
the external device is attached, second storage means
for storing second control information for controlling
25 the position of the movable lens means when the external
device is not attached, and control means for reading

out contents of the first or second storage means in accordance with a detection result of the detection means, and controlling the drive means using the first or second control information.

5 A lens apparatus according to the present invention is characterized by the following arrangement.

That is, there is provided a lens apparatus comprising movable lens means for forming an object image on a predetermined plane while moving along an optical axis, drive means for driving the movable lens means, connection means for detachably attaching an external device, detection means for detecting attachment/detachment of the external device, first storage means for storing control information for
10 controlling a position of the movable lens means when the external device is attached, second storage means for storing correction data for correcting the control information, and control means for reading out contents of the first and/or second storage means in accordance
15 with a detection result of the detection means, and controlling the drive means using the control information when the external device is not attached or using control information obtained by correcting the control information by the correction data when the
20 external device is attached.
25

A storage medium according to the present invention

is characterized by the following arrangement.

That is, there is provided a computer-readable storage medium storing a program for executing a sequence of detecting if an external device is attached,
5 and a sequence of controlling a position of a movable lens using first control information when it is detected that the external device is not attached, and controlling the position of the movable lens using second control information when it is detected that the
10 external device is attached.

A storage medium according to the present invention is characterized by the following arrangement.

That is, there is provided a computer-readable storage medium storing a program for executing a
15 sequence of detecting if an external device is attached, and a sequence of controlling a position of a movable lens using control information when it is detected that the external device is not attached, and controlling the position of the movable lens using control information
20 obtained by correcting the control information by correction data when it is detected that the external device is attached.

A storage medium according to the present invention is characterized by the following arrangement.

25 That is, there is provided a computer-readable storage medium storing correction data for correcting

control information that controls a position of a
movable lens when an external device is attached to a
lens apparatus having a movable lens.

A storage medium according to the present invention
5 is characterized by the following arrangement.

That is, there is provided a computer-readable
storage medium storing correction data for correcting
control information that controls a position of a
movable lens when an external apparatus is attached to a
10 lens apparatus having the movable lens.

An imaging apparatus according to the present
invention is characterized by the following arrangement.

That is, there is provided an imaging apparatus
which has a lens system including a zoom lens group for
15 changing a field angle and a focus compensation lens
group having both a function of correcting a change in
focal plane position upon movement of the zoom lens
group and a focus adjustment function, and storage means
for storing a locus that represents a positional
20 relationship between the zoom lens group and focus
compensation lens group in an in-focus state in
correspondence with an object distance, and moves the
zoom lens group and focus compensation lens group to
trace the locus stored in the storage means upon zooming,
25 comprising generation means for generating a video
signal by photoelectrically converting an optical image

obtained via the lens system, discrimination means for discriminating an in-focus level and a direction to drive to reach an in-focus point by detecting focus states at a predetermined period from the video signal
5 generated by the generation means and comparing the focus states upon zooming, and determination means for determining the period on the basis of a moving speed of the zoom lens group.

An imaging method according to the present
10 invention is characterized by the following arrangement.

That is, there is provided an imaging method for an imaging apparatus which has a lens system including a zoom lens group for changing a field angle and a focus compensation lens group having both a function of
15 correcting a change in focal plane position upon movement of the zoom lens group and a focus adjustment function, and storage means for storing a locus that represents a positional relationship between the zoom lens group and focus compensation lens group in an in-
20 focus state in correspondence with an object distance, and moves the zoom lens group and focus compensation lens group to trace the locus stored in the storage means upon zooming, comprising the generation step of generating a video signal by photoelectrically
25 converting an optical image obtained via the lens system, the discrimination step of discriminating an in-focus

level and a direction to drive to reach an in-focus point by detecting focus states at a predetermined period from the video signal generated in the generation step and comparing the focus states upon zooming, and
5 the determination step of determining the period on the basis of a moving speed of the zoom lens group.

A storage medium according to the present invention is characterized by the following arrangement.

That is, there is provided a storage medium which
10 is used in an imaging apparatus having a lens system including a zoom lens group for changing a field angle and a focus compensation lens group having both a function of correcting a change in focal plane position upon movement of the zoom lens group and a focus
15 adjustment function, and storage means for storing a locus that represents a positional relationship between the zoom lens group and focus compensation lens group in an in-focus state in correspondence with an object distance, and which stores a program for moving the zoom
20 lens group and focus compensation lens group to trace the locus stored in the storage means upon zooming, the program stored in the storage medium including a generation routine for generating a video signal by photoelectrically converting an optical image obtained
25 via the lens system, a discrimination routine for discriminating an in-focus level and a direction to

drive to reach an in-focus point by detecting focus states at a predetermined period from the video signal generated in the generation routine and comparing the focus states upon zooming, and a determination routine
5 for determining the period on the basis of a moving speed of the zoom lens group.

A lens control apparatus according to the present invention is characterized by the following arrangement.

That is, there is provided a lens control apparatus
10 comprising a zoom lens, a focus lens, focus detection means for detecting a focus state from a video signal at a predetermined period, focus control means for controlling the focus lens on the basis of an output from the focus detection means; and control means for
15 changing the period on the basis of a moving speed of the zoom lens.

A lens control method according to the present invention is characterized by the following arrangement.

That is, there is provided a lens control method
20 comprising the focus detection step of detecting a focus state from a video signal at a predetermined period in an imaging apparatus having a zoom lens and focus lens, the focus control step of controlling the focus lens on the basis of an output from the focus detection step,
25 and the control step of changing the period on the basis of a moving speed of the zoom lens.

An imaging apparatus according to the present invention is characterized by the following arrangement.

That is, there is provided an imaging apparatus which has a lens system including a zoom lens group for
5 changing a field angle and a focus compensation lens group having both a function of correcting a change in focal plane position upon movement of the zoom lens group and a focus adjustment function, and storage means for storing a locus that represents a positional
10 relationship between the zoom lens group and focus compensation lens group in an in-focus state in correspondence with an object distance, and moves the zoom lens group and focus compensation lens group to trace the locus stored in the storage means upon zooming,
15 comprising selection means for selecting the locus on the basis of positions of the zoom lens group and focus compensation lens group, detection means for detecting an in-focus level; and control means for determining a moving amount of the focus compensation lens group on
20 the basis of the selected locus information, the in-focus level detected by the detection means upon zooming, and a moving speed of the zoom lens group.

An imaging method according to the present invention is characterized by the following arrangement.

25 That is, there is provided an imaging method for an imaging apparatus which has a lens system including a

zoom lens group for changing a field angle and a focus
compensation lens group having both a function of
correcting a change in focal plane position upon
movement of the zoom lens group and a focus adjustment
5 function, and storage means for storing a locus that
represents a positional relationship between the zoom
lens group and focus compensation lens group in an in-
focus state in correspondence with an object distance,
and moves the zoom lens group and focus compensation
10 lens group to trace the locus stored in the storage
means upon zooming, comprising the selection step of
selecting the locus on the basis of positions of the
zoom lens group and focus compensation lens group, the
detection step of detecting an in-focus level, and the
15 control step of determining a moving amount of the focus
compensation lens group on the basis of the selected
locus information, the in-focus level detected in the
detection step upon zooming, and a moving speed of the
zoom lens group.

20 A storage medium according to the present invention
is characterized by the following arrangement.

That is, there is provided a storage medium which
is used in an imaging apparatus having a lens system
including a zoom lens group for changing a field angle
25 and a focus compensation lens group having both a
function of correcting a change in focal plane position

upon movement of the zoom lens group and a focus
adjustment function, and storage means for storing a
locus that represents a positional relationship between
the zoom lens group and focus compensation lens group in
5 an in-focus state in correspondence with an object
distance, and which stores a program for moving the zoom
lens group and focus compensation lens group to trace
the locus stored in the storage means upon zooming, the
program including a selection routine for selecting the
10 locus on the basis of positions of the zoom lens group
and focus compensation lens group, a detection routine
for detecting an in-focus level, and a control routine
for determining a moving amount of the focus
compensation lens group on the basis of the selected
15 locus information, the in-focus level detected in the
detection routine upon zooming, and a moving speed of
the zoom lens group.

A lens control apparatus according to the present
invention is characterized by the following arrangement.

20 That is, there is provided a lens control apparatus
comprising a zoom lens, a focus lens having a function
of correcting a change in focal plane position upon
movement of the zoom lens, storage means for storing a
locus representing a positional relationship between the
25 zoom lens and focus lens in an in-focus state in
correspondence with an object distance, detection means

for detecting an in-focus level, selection means for selecting the locus on the basis of position information of the zoom lens and focus lens, and control means for calculating a moving amount of the focus lens to move
5 the focus lens according to the locus on the basis of the locus information selected by the selection means and the in-focus level detected by the detection means, and changing the moving amount of the focus lens in correspondence with a moving speed of the zoom lens.

10 A lens control apparatus according to the present invention is characterized by the following arrangement.

That is, there is provided a lens control apparatus comprising a zoom lens, a focus lens having a function of correcting a change in focal plane position upon
15 movement of the zoom lens, storage means for storing a locus representing a positional relationship between the zoom lens and focus lens in an in-focus state in correspondence with an object distance, detection means for detecting an in-focus level, and control means for
20 selecting the locus in accordance with position information of the zoom lens and focus lens, the in-focus level detected by the detection means, and a moving speed of the zoom lens, and controlling a moving amount which makes the focus lens trace the locus.

25 Other objects and advantages besides those discussed above shall be apparent to those skilled in

the art from the description of a preferred embodiment of the invention which follows. In the description, reference is made to accompanying drawings, which form a part thereof, and which illustrate an example of the invention. Such example, however, is not exhaustive of the various embodiments of the invention, and therefore reference is made to the claims which follow the description for determining the scope of the invention.

10

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing cam loci;

Fig. 2 is a graph for explaining necessity for changing the cam loci;

15

Fig. 3 is a graph showing an example of conventional changing processing of cam loci on the basis of blur recognition during zooming;

Fig. 4 is a diagram showing the arrangement according to the first embodiment of the present invention;

20

Fig. 5 is a graph for explaining cam correction data;

Fig. 6 is a flow chart of the first embodiment;

Fig. 7 is a diagram showing the arrangement according to the second embodiment of the present invention;

25

Fig. 8 is a flow chart of the second embodiment;

Fig. 9 is a diagram showing the arrangement according to the third embodiment of the present invention;

5 Fig. 10 is a graph showing the lens position of the third embodiment;

Fig. 11 is a diagram showing the arrangement according to the fourth embodiment of the present invention;

10 Fig. 12 is a diagram showing the arrangement according to the fifth embodiment of the present invention;

Fig. 13 is a graph showing cam loci with and without an extender attached;

15 Fig. 14 is a flow chart of the fifth embodiment;

Fig. 15 is a diagram showing the arrangement according to the sixth embodiment of the present invention;

20 Fig. 16 is a graph for explaining cam correction data;

Fig. 17 is a flow chart of the sixth embodiment;

Fig. 18 is a diagram showing the arrangement according to the seventh embodiment of the present invention;

25 Fig. 19 is a flow chart of the seventh embodiment;

Fig. 20 is a schematic block diagram showing the

arrangement of an imaging apparatus according to the eighth embodiment of the present invention;

Fig. 21 is a graph showing cam loci;

Fig. 22 is a graph showing examples of changes in
5 AF signal upon driving a variator at the sampling periods of the AF signal and at intermittent periods;

Fig. 23 is a flow chart showing cam locus tracing during zooming in the eighth embodiment;

Fig. 24 is a schematic block diagram showing the
10 arrangement of an imaging apparatus according to the ninth embodiment of the present invention;

Fig. 25 is a schematic block diagram showing the arrangement of an imaging apparatus according to the 10th embodiment of the present invention;

Fig. 26 is a flow chart showing cam locus tracing during zooming in the 10th embodiment of the present invention;

Fig. 27 is a schematic block diagram showing the arrangement of an imaging apparatus according to the
20 11th embodiment of the present invention;

Fig. 28 is a graph showing examples of stepwise changes in focus moving amount used for changing the cam loci in correspondence with the blur level and zooming speed;

Fig. 29 is a graph showing examples of continuous changes in focus moving amount used for changing the cam

loci in correspondence with the blur level and zooming speed;

Fig. 30 is a flow chart showing focusing during zooming; and

5 Fig. 31 is a schematic block diagram showing the arrangement of an imaging apparatus according to the 12th embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

10

The preferred embodiments of the present invention will be described in detail hereinafter with reference to the accompanying drawings.

(First Embodiment)

15 Fig. 4 is a schematic diagram showing principal part of an optical equipment according to the first embodiment of the present invention.

Referring to Fig. 4, reference numeral 1 denotes an optical system which is constructed by a 4-group rear-
20 focus zoom lens (to be abbreviated as an "RFZ lens" hereinafter) including four lens groups. The RFZ lens 1 is constructed by a first lens group (to be referred to as a "front lens" hereinafter) 101 as a stationary lens group, a second lens group (to be referred to as a
25 "variator" hereinafter) 102 as a movable lens group having a zooming function, a third lens group (to be

referred to as an "afocal" hereinafter) 103 as a stationary lens group, and a fourth lens group (to be referred to as an "RR" hereinafter) 104 which is a movable lens group, and has a focusing function, and a compensator function of correcting variations of the image plane upon zooming of the variator 102. Reference symbol P denotes an optical axis of the optical system 1.

Note that each lens group is constituted by a plurality of lenses in practice. For example, in this embodiment, the front lens 101 has three lenses, the variator 102 three lenses, the afocal 103 a single lens, and the RR 104 two lenses; a total of nine lenses. However, the number of lenses of each lens group is not particularly limited.

Reference numeral 102a denotes a holding member (to be referred to as a "V moving ring" hereinafter) for holding the variator 102; and 104a, a holding member (to be referred to as an "RR moving ring" hereinafter) for holding the RR 104. These rings 102a and 104a are manufactured by molding or grinding using a plastic material such as polycarbonate or the like mixed with glass fiber.

Reference numeral 2 denotes a holding member (to be referred to as a "lens barrel" hereinafter) of the respective lens groups. The lens barrel 2 is manufactured by molding or grinding using a plastic

material such as polycarbonate or the like.

Note that the lens barrel 2, and moving rings 102a and 104a may also be manufactured by die-casting a metal material such as aluminum, titanium, or the like, by
5 secondary working after die-casting, or by directly grinding a block. Furthermore, the lens barrel 2 may be formed by dividing it into some pieces. For example, the lens barrel 2 may be formed by a plurality of members divided parallel or perpendicular to the optical axis P.

10 Reference numerals 101a and 103a denote holding members for fixing the front lens 101 and afocal 103 to the lens barrel 2. Note that the front lens 101 and afocal 103 may be directly fixed to the lens barrel 2 using, e.g., an adhesive. Reference numeral 18 denotes a
15 photoelectric conversion element such as a CCD or the like.

Reference numeral 3 denotes a mechanical stop member for adjusting the amount of light that becomes incident on the photoelectric conversion element 18. In
20 the mechanical stop member 3, aperture blades 3a are driven by a stop driver 7 comprising, e.g., an iG meter, stepping motor, or the like in a direction nearly perpendicular to the optical axis P, thereby varying the area of an aperture 3b. Reference numeral 9 denotes a
25 stop encoder which detects the rotational angle of the iG meter. Reference numeral 22 denotes a detection

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circuit for detecting a signal output from the stop
encoder 9; 16, a stop drive circuit; and 20, a stop
controller. The mechanical stop member 3, stop driver 7,
and stop encoder 9 construct a stop unit. However, the
5 present invention is not limited to such specific stop
unit. For example, a so-called solid-state stop having,
e.g., an electrochromy function of controlling the
transmittance of light by an electrochemical effect.

Reference numeral 4 denotes a filter unit placed in
10 front of the photoelectric conversion unit 18. The
filter unit 4 is composed of an optical low-pass filter
4a such as quartz, and an infrared cut filter 4b. These
filters 4a and 4b are integrally placed in front of the
photoelectric conversion element 18, but may be
15 separately placed or may be inserted at arbitrary
positions of the RFZ lens 1 where they are fully
functional.

Reference numerals 5 and 6 denote lens drivers
including stepping motors and the like for driving the
20 movable lens groups 102 and 104. Reference numerals 5a
and 6a denote lead screws, the surfaces of which have
threads at a predetermined pitch. Reference numerals
102b and 104b denote racks, which are respectively
formed integrally with the V and RR moving rings 102a
25 and 104a. These racks 102b and 104b mesh with the lead
screws 5a and 6a, and the V and RR moving rings 102a and

104b move parallel to the optical axis P upon forward/reverse rotation of the stepping motors 5 and 6, thereby moving the variator 102 and RR 104 parallel to the optical axis P.

5 Reference numerals 8a and 10a denote photointerrupters; and 8b and 10b, light-shielding plates, which are respectively formed integrally with the V and RR moving rings 102a and 104a by molding or grinding. When these light-shielding plates 8b and 10b reach the positions of the photointerrupters 8a and 10a upon movement of the V and RR moving rings 102a and 104a, signals output from the photointerrupters 8a and 10a change, and the reference positions (to be referred to as "lens initial reset positions" hereinafter) of the variator 102 and RR 104 are determined by detecting these changes. In this embodiment, by counting the number of drive pulses for driving each stepping motor with respect to the lens initial reset position, relative position information of each lens from the initial reset position is detected. Reference numerals 21 and 23 denote detection circuits for detecting signals output from the photointerrupters 8a and 10a.

 Note that this embodiment uses a combination of a photointerrupter and light-shielding plate as lens initial reset position detection means. Instead, a combination of a Hall element and magnet, that of a PSD

and iRED, and the like may be used.

Also, this embodiment uses a combination of a stepping motor and lens initial reset position detection means. Alternatively, a combination of a voice coil
5 motor, DC motor, or the like, and lens position detection means comprising a combination of a magnetoresistive effect element and magnet, or the like may be used.

Reference numeral 13 denotes a controller for
10 controlling the overall equipment; and 15 and 17, lens drive circuits for driving the lens drivers 5 and 6. Reference numeral 19 denotes a camera process unit for processing the output signal from the photoelectric conversion element 18 and outputting the processed
15 signal as an image signal. Reference numeral 14 denotes a memory for storing control information shown in Fig. 1 for controlling the variator 102 and RR 104; and 25, a correction data memory which constructs a storage medium according to the present invention, that stores cam
20 correction data for correcting the control information.

Reference numeral 11 denotes a zoom switch. A zoom switch 11a is pressed upon zooming toward the wide-angle end (to be referred to as "WIDE" hereinafter), and a zoom switch 11b is pressed upon zooming toward the
25 telephoto end (to be referred to as "TELE" hereinafter). Upon depression of the zoom switch, the variator 102 and

RR 104 are driven in accordance with drive signals from the controller 13 so as to attain zooming. Reference numeral 24 denotes a power supply.

Fig. 1 shows cam loci obtained by plotting the stop positions of the variator 102 and RR 104 on the optical axis in units of object distances.

In the RFZ lens 1, the stop position of the RR 104 on the optical axis is determined with respect to the lens stop position of the variator 102, i.e., zoom position, in units of object distances, so as to attain zooming while maintaining an in-focus state.

Referring to Fig. 1, for example, when the object distance is infinity (or 2 m), the RR lens 104 moves along convex locus curve Y_{∞} (or Y_2) toward the object side upon movement of the variator 102 from WIDE to TELE on the optical axis.

Fig. 5 is a graph that compares theoretically obtained cam locus (stored cam locus) b and true cam locus a after the manufacture. Note that the object distance the cam traces is arbitrary. As can be seen from Fig. 5, theoretical cam locus b and actual cam locus a have a difference. Differential locus c expresses that difference as a locus. When this differential locus c is stored in the correction data memory 25 as cam correction data, the theoretical cam locus matches the actual one, and high-precision cam

trace free from blurring can be realized.

More specifically, the theoretical cam loci are stored as center values of the cam, and the cam correction data are also stored to correct deviations of the cam loci due to the aforementioned manufacturing errors and the like, thus realizing accurate cam trace.

Fig. 6 is a flow chart showing the actual processing flow.

Initially, the power supply 24 is turned on (step S10). The signals output from the photointerrupters 8a and 10b are read via the detection circuits 21 and 23 (step S11). The controller 13 then drives the variator 102 and RR 104 in a direction corresponding to the read signals, i.e., in a direction to make the signals from the detection circuits 21 and 23 go low if the read signals are high, or vice versa (step S12). It is then checked if the signals from the photointerrupters 8a and 10a have changed (step S13). If the signals remain the same, the controller continues to drive; otherwise, the flow advances to step S14.

The positions of the variator 102 and RR 104 when the signals from the photointerrupters 8a and 10a have changed are determined as initial reset positions (step S14). The variator 102 and RR 104 are stopped at these positions where the signals have changed, and internal counters for the variator 102 and RR 104 in the

controller 13 are cleared (step S15). These counters
count drive pulses of the variator 102 and RR 104,
thereby detecting the relative current positions of the
variator 102 and RR 104 from their initial reset
5 positions.

It is then checked if the zoom switch 11 is being
pressed (step S16). If the zoom switch 11a is being
pressed, zooming is made in the WIDE direction; if the
zoom switch 11b is being pressed, zooming is made in the
10 TELE direction. If the zoom switch 11b is not pressed,
zooming is not done (step S17).

Zooming in the TELE direction will be explained
below. Since zooming in the WIDE direction is controlled
by the same routine, a description thereof will be
15 omitted.

A position PV of the variator 102 is read out from
the counter to search a divided region where the
variator 102 is currently in, thereby determining a
current region PVV of the variator 102 (step S18).
20 Similarly, representative position data PRR of the RR
104 corresponding to the current region PVV of the
variator 102 is read out from the counter (step S19).

Cam correction data is then read out from the
correction data memory 25 (step S20). A correction
25 amount T is then calculated in consideration of the
positions of the RR and variator, or correction toward

the closest-distance side or infinity side (step S21).

An extending amount PRRT is calculated (step S22)

by:

$$\text{PRRT} = T + \text{PRR} \quad \dots(1)$$

- 5 Note that $T = 0$ when the actual cam locus matches the theoretical value. The variator 102 and RR 104 are driven according to the calculated data (step S23).

Note that the above description about zooming is premised on that auto-focusing is not activated during
10 zooming. However, no problem is posed even when auto-focusing is activated.

According to this embodiment, for example, when the differences between the theoretical and actual cam loci have a given quantitative tendency in a mass-production
15 lot, these differences are stored in the correction data memory 25 as cam correction data, thus realizing cam trace with much higher precision than that of the theoretical cam locus alone in the conventional system.

When the cam correction data (memory 25) are stored
20 in a rewritable storage device, they can be easily changed in correspondence with mass-production lots, and this embodiment is very effective in terms of labor, schedule, and cost.

Note that the optical equipment may be constructed
25 by a detachable camera apparatus and lens apparatus.

(Second Embodiment)

Fig. 7 is a block diagram showing the second embodiment of the present invention. The same reference numerals in Fig. 7 denote the same parts as in Fig. 4, and a repetitive description thereof will be avoided.

5 Referring to Fig. 7, reference numeral 26 denotes a cam correction ON/OFF unit, which can be implemented by either an external switch or a rewritable storage device.

This embodiment has as its object to easily cope with a situation where the need for arbitrary ON/OFF
10 control of cam correction arises for various reasons, e.g., when sufficiently high performance can be assured without cam correction, when measurement is made upon comparing theoretical and actual cam loci, and so forth.

Fig. 8 is a flow chart of the processing of this
15 embodiment.

In Fig. 8, step S19a is added after step S19 in the flow chart shown in Fig. 6. Hence, since other processes are the same as those in Fig. 6, a detailed description thereof will be omitted.

20 It is checked in step S19a if cam correction is ON. If NO in step S19a, the flow jumps to step S22 to calculate the RR extending amount; otherwise, the correction data is read out in step S20. Note that checking in step S19a may be made based on data pre-
25 stored in a rewritable storage medium or on the positions of the variator and RR.

(Third Embodiment)

Fig. 9 shows the arrangement of a video camera which can exchange a lens, according to the third embodiment of the present invention.

5 Referring to Fig. 9, a lens unit 115 is detachably, electrically and mechanically connected to a camera unit 116 via contacts 131 and 132.

A light beam from an object is transmitted through a stationary first lens group 201, a variator lens group
10 202 as a second lens group that attains zooming, a stop 203, a stationary third lens group 204, and a focus lens group 200 as a fourth lens group having both a focus adjustment function and a compensation function of compensating for movement of the focal plane upon
15 zooming. Then, red, green, and blue components as the three primary colors of the light beam respectively form images on imaging elements 128, 129, and 130 comprising, e.g., CCDs. The absolute positions of the variator lens group 202 and focus lens group 200 are respectively
20 detected by absolute position detectors 202A and 200A such as encoders or the like, and the detected positions are supplied to a lens microcomputer 110.

The images on the respective imaging elements are photoelectrically converted into electrical signals,
25 which are amplified to optimal levels by amplifiers 105, 106, and 107. Then, the amplified signals are input to a

camera signal processing circuit 108 and are converted into a standard television signal. At the same time, AF information is read out as an AF evaluation value by a data read-out program 121 of a camera microcomputer 109.

5 The AF evaluation value read out by the camera microcomputer 109 is transferred to the lens microcomputer 110 via the camera contact 131 and lens contact 132 in combination with information of switches on the camera side, such as the ON/OFF state of an AF
10 switch, the state of a zoom switch, and the like (these switches are not shown). If it is determined based on the information from the camera microcomputer 109 that the zoom switch is being pressed, the lens microcomputer 110 supplies a signal to a zoom motor driver 112 to
15 drive the variator lens group 202 via a zoom motor 111 toward TELE or WIDE, i.e., in the direction the switch is being pressed. At the same time, a signal is supplied to a focus motor driver 114 using a program in a
20 controller 124 on the basis of lens cam data 125 pre-stored in the lens microcomputer 110 to move the focus lens group 200 via a focus motor 113, thus attaining zooming free from any focus movement.

 In a lens system in which a correction lens (focus lens) is placed behind a zoom lens (variator lens) on
25 the optical axis, as shown in Fig. 9, the control position of the correction lens changes depending on the

object distance while an in-focus state is maintained upon zooming. The lens cam data 125 stores the positions of the focus lens group 200 in units of a plurality of absolute positions of variator lens group 202 and in
5 units of absolute positions of object distances (e.g., 1 m and 2 m in Fig. 10), as shown in Fig. 10. The program in the controller 124 determines the rotation direction and velocity of the focus motor 113 using the lens cam data 125 selected based on the absolute position data of
10 the variator lens group 202 and focus lens group 200 detected by the position detectors 202A and 200A.

When the AF switch on the camera unit is ON, an AF controller 123 in the lens microcomputer 110 supplies a signal to the focus motor driver 114 via the controller
15 124 and a motor controller 126 to maximize the AF evaluation value from the camera microcomputer 109 and to move the focus lens group 200 alone, thus attaining automatic focus adjustment.

In this embodiment, in the video camera that can
20 exchange a lens, the aforementioned cam trace calculation is made by the lens microcomputer 110. Hence, the processing is done in the same manner as that in the flow chart shown in Fig. 6 according to the first embodiment.

25 (Fourth Embodiment)

Fig. 11 shows the fourth embodiment of the present

invention. In Fig. 11, a cam correction ON/OFF unit 124,
which comprises an external switch or a rewritable
storage device, is added to Fig. 9. This embodiment can
easily cope with a situation where the need for
5 arbitrary ON/OFF control of cam correction arises for
various reasons, e.g., when sufficiently high
performance can be assured without cam correction, when
measurement is made upon comparing theoretical and
actual cam loci, and so forth, as in the second
10 embodiment. The processing is the same as that shown in
Fig. 8.

Note that the system made up of the functional
blocks shown in Figs. 4, 7, 9, and 11 may be implemented
by hardware or using a microcomputer system comprising a
15 CPU, memory, and the like. When a microcomputer system
is used, the memory constructs a storage medium
according to the present invention. This storage medium
stores a program for executing the processing shown in
the flow chart in Fig. 6 or 8. For this storage medium
20 and that as the correction data memory 25, a
semiconductor memory such as a ROM, RAM, or the like,
optical disk, magnetooptical disk, magnetic medium, and
the like may be used, or they may be used as a CD-ROM,
floppy disk, magnetic tape, nonvolatile memory card, and
25 the like.

To restate, according to the first to fourth

embodiments, since conventional control information is stored without any modification, and correction data for correcting deviations produced by, e.g., manufacturing errors are also stored, high-precision lens control can
5 be done with less labor and lower cost by controlling lens driving using these data. Even when the image quality and magnification become higher in the future, blur will hardly be recognized.

(Fifth Embodiment)

10 Fig. 12 is a diagram showing the arrangement of a video camera that can exchange a lens, according to the fifth embodiment of the present invention.

Referring to Fig. 12, a lens unit 315 is detachably attached to a camera unit 316 via an extender 337. The
15 lens unit 315 has a lens contact 332, the extender 337 has an extender lens contact 334 and extender camera contact 333, and the camera unit 315 has a camera contact 331.

A light beam from an object is transmitted through
20 a stationary first lens group 301, a variator lens group (to be referred to as a variator hereinafter) 302 as a second lens group that attains zooming, a stop 303, a stationary third lens group 304, and a focus lens group (to be referred to as an RR hereinafter) 300 as a fourth
25 lens group having both a focus adjustment function and a compensation function of compensating for movement of

the focal plane upon zooming, and is also transmitted through an extender lens group 335 for zooming in the extender 337. Then, red, green, and blue components as the three primary colors of the light beam respectively
5 form images on imaging elements 328, 329, and 330 comprising, e.g., CCDs.

The absolute positions of the variator 302 and RR 300 are respectively detected by absolute position detectors 302A and 300A such as encoders or the like,
10 and the detected positions are supplied to a lens microcomputer 310. The images on the respective imaging elements 328 to 330 are photoelectrically converted into electrical signals, which are amplified to optimal levels by amplifiers 305, 306, and 307. Then, the
15 amplified signals are input to a camera signal processing circuit 308 and are converted into a standard television signal. At the same time, AF information is read out as an AF evaluation value by a data read-out program 321 of a camera microcomputer 309.

20 The AF evaluation value read out by the camera microcomputer 309 is transferred to the microcomputer 310 via the camera contact 331, the extender camera contact 333, an extender internal circuit 336, the extender lens contact 334, and the lens contact 332
25 together with information of switches on the camera side such as the ON/OFF state of an AF switch, the state of a

zoom switch, and the like (these switches are not shown).

If it is determined based on information from the camera microcomputer 309 that the zoom switch is being pressed, the lens microcomputer 310 supplies a signal to
5 a zoom motor driver 312 to drive the variator 302 via a zoom motor 311 toward TELE or WIDE, i.e., in the direction the switch is being pressed. At the same time, a motor controller 326 supplies a signal to a focus motor driver 314 using a program in a controller 324 on
10 the basis of lens cam data 325 pre-stored in the lens microcomputer 310 to move the RR 300 via a focus motor 313, thus attaining zooming free from any focus movement.

When the AF switch on the camera unit is ON, an AF controller 323 in the lens microcomputer 310 supplies a
15 signal to the focus motor driver 314 via the controller 324 and motor controller 326 to maximize the AF evaluation value from the camera microcomputer 309 and to move the RR 300 alone, thus attaining automatic focus adjustment.

20 When the stop positions of the variator 302 and RR 300 on the optical axis are plotted in units of object distances, the above-mentioned graph shown in Fig. 1 is obtained.

Referring to Fig. 1, for example, when the object
25 distance is infinity (or 2 m), the RR lens 300 moves along convex locus Y_{∞} (or Y_2) toward the object side

upon movement of the variator from WIDE to TELE on the optical axis. As described above, upon zooming from WIDE toward TELE or vice versa, driving of the variator 302 and RR 300 is controlled to trace the cam locus in
5 correspondence with the object distance, thus obtaining a good image free from any blur.

However, as shown in Fig. 13, a cam locus used when the lens unit 315 alone has a large difference from that used upon attaching the extender 337 (with and without
10 Ext: Ext represents the extender). The cam loci shown in Fig. 13 are obtained by plotting the stop positions of the variator 302 and RR 300 on the optical axis for a given identical object distance.

In order to solve this problem, in this embodiment,
15 whether or not the extender is attached is detected, and optical and mechanical changes in cam locus by the extender 337 attached are stored in advance, thus attaining high-precision cam trace by a method that requires less labor and lower cost.

20 More specifically, when the extender 337 is attached, the lens microcomputer 310 controls by reading out extender cam data 327 upon attachment of the extender, which is different from cam data used for the lens unit 315 alone, thereby realizing satisfactory cam
25 trace free from blurring even when the extender is attached.

Fig. 14 is a flow chart showing the actual flow.

After power ON, predetermined reset operations of both the variator 302 and RR 300 are performed to detect the positions of these lens for cam trace. In this case,
5 internal counters are initialized by the reset operations to prepare for control.

It is checked in step S101 if a zoom drive command is detected. If NO in step S101, zooming is not made. A drive command means may be placed in either the lens
10 unit 315 or the camera unit 316. If YES in step S101, the zooming speed is read in step S102. The drive command means may designate an arbitrary speed depending on its shape, or a fixed speed may be designated. That is, the present invention is not limited to a specific
15 speed.

It is then checked in step S103 if the extender 337 is attached. A signal from the camera unit 316 is input to the lens microcomputer 310 via the contacts 331, 333, and 334. The lens microcomputer 310 can determine
20 attachment of the extender 337 using the extender internal circuit 336.

If the extender 337 is not attached, the lens cam data 325 as cam locus data for the lens unit 315 alone is read from a memory in step S104.

25 If the extender 337 is attached, the extender cam data 327 as cam locus data with the extender is read

from the memory in step S105. The extending amount of the RR 300 is calculated in step S106, and the variator 302 and RR 300 are driven on the basis of the calculated data in step S107.

5 Note that the above description about zooming is premised on that auto-focusing is not activated during zooming. However, no problem is posed even when auto-focusing is activated.

(Sixth Embodiment)

10 Fig. 15 shows the sixth embodiment of the present invention.

 The arrangement shown in Fig. 15 is substantially the same as that shown in Fig. 12, except that extender cam correction data 339 is stored in place of the
15 extender cam data 327 in Fig. 12.

 Fig. 16 is a graph that plots the stop positions of the variator 302 and RR 300 on the optical axis for a given identical object distance. As can be seen from Fig. 16, a cam locus for the lens unit 316 alone has a large
20 difference from that upon attaching the extender. Note that the cam traces an arbitrary object distance in Fig. 16. Also, a differential locus in Fig. 16 indicates the difference between the two loci.

 When this differential locus is stored as the
25 extender cam correction data 339 as another cam correction locus data, the theoretical cam locus can

match the actual one, and ideal cam trace free from any blurring can be realized.

In this embodiment, whether or not the extender is attached is detected, and optical and mechanical changes in cam locus by the extender 337 attached can be corrected by storing both the cam locus data (lens cam data 325) for the lens unit 315 alone, and the extender cam data 339 for correcting these data, thus realizing high-precision cam trace that requires less labor and lower cost.

Fig. 17 is a flow chart showing the actual flow.

Steps S111 and S112 after the start are executed in the same manner as in steps S101 and S102 in Fig. 14. In step S113, the lens cam data 325 is read. It is then checked in step S114 if the extender 337 is attached. A signal from the camera unit 316 is input to the lens microcomputer 310 via the contacts 331, 333, 334, and 332. The lens microcomputer 310 can determine attachment of the extender 337 by using the internal circuit 336. If the extender 337 is attached, the extender cam correction data 339 for a case with the extender is read in step S115.

In step S116, the extending amount of the RR 300 is calculated by:

$$PRRT = T + PRR \quad \dots (2)$$

In this case, the correction amount is calculated in

consideration of the positions of the RR 300 and
variator 302, or correction toward the closest-distance
side or infinity side. Of course, $T = 0$ when the cam
locus upon attachment of the extender 337 matches that
5 without the extender. In step S117, the variator 302 and
RR 300 are driven based on the calculated data.

Note that the above description about zooming is
premised on that auto-focusing is not activated during
zooming. However, no problem is posed even when auto-
10 focusing is activated.

When the extender cam correction data 328 are
stored in a rewritable storage device, they can be
easily changed in correspondence with mass-production
lots, and this embodiment is very effective in terms of
15 labor, schedule, and cost.

(Seventh Embodiment)

Fig. 18 shows the seventh embodiment of the present
invention. In Fig. 18, a cam correction ON/OFF unit 330
upon attachment of the extender is added to Fig. 15. The
20 cam correction ON/OFF unit 330 can be implemented by
either an external switch or a rewritable storage device.

This embodiment can easily cope with a situation
where the need for arbitrary ON/OFF control of cam
correction arises for various reasons, e.g., when
25 sufficiently high performance can be assured without
correcting cam trace for the lens unit 315 alone upon

attachment of the extender 337, when measurement is made upon comparing cam loci with and without the extender attached, and so forth.

Fig. 19 shows the flow. In Fig. 19, step S114A is
5 inserted after step S114 in Fig. 17. It is checked in step S114A if cam correction is ON when the extender is attached. If NO in step S114A, the flow jumps to step S116 to calculate the RR extending amount; otherwise, the extender cam correction data 330 is read out in step
10 S115. Note that checking in step S114A may be made based on data pre-stored in a rewritable storage medium or on the positions of the variator and RR.

In the above description, auto-focusing may be activated during zooming.

15 Note that storage media 320 and 322 shown in Figs. 12, 15, and 18 store programs for executing the processing shown in the flow charts shown in Figs. 14, 17, and 19. As the storage medium, a semiconductor memory such as a ROM, RAM, or the like, optical disk,
20 magneto-optical disk, magnetic medium, and the like may be used, and they may be used as a CD-ROM, floppy disk, magnetic tape, nonvolatile memory card, and the like.

To reiterate, according to the fifth to seventh embodiments, since control information of a movable lens
25 upon attachment of an external device such as an extender or correction data for correcting the control

information is stored, high-precision cam trace can be realized with less labor and lower cost. Also, even when the image quality and magnification become higher in the future, blur will hardly be recognized.

5 (Eighth Embodiment)

Fig. 20 is a schematic block diagram showing the arrangement of an imaging apparatus according to the eighth embodiment of the present invention. Referring to Fig. 20, reference numeral 401 denotes an optical system
10 which is constructed by a 4-group rear-focus zoom lens (to be abbreviated as an "RFZ lens" hereinafter) including four lens groups. More specifically, the RFZ lens 401 is constructed by a first lens group (to be referred to as a front lens hereinafter) 501 as a
15 stationary lens group, a second lens group (to be referred to as a variator hereinafter) 502 as a movable lens group having a zooming function, a third lens group (to be referred to as an afocal hereinafter) 503 as a stationary lens group, and a fourth lens group (to be
20 referred to as a focus compensation lens hereinafter) 504 which is a movable lens group, and has a focusing function, and a compensator function of correcting variations of the image plane upon zooming.

Reference numeral 402 denotes a photoelectric
25 conversion element such as a CCD; 403, a stop for adjusting the amount of light that becomes incident on

the photoelectric conversion element 402; 404, a stop driver for changing the aperture area of the stop 403; 405, a stop position detector for detecting the position of the stop 403; 406, a detection circuit for detecting the aperture area (stop amount) of the stop 403 on the basis of the output signal from the stop position detector 405; and 407, a controller for systematically controlling imaging by the imaging apparatus of this embodiment.

10 Note that the controller 407 comprises a microcomputer, and has a CPU, ROM, and RAM (not shown). The ROM stores cam loci shown in Fig. 21, and control programs and the like corresponding to the flow charts shown in Figs. 23 and 26. The CPU controls various kinds of processing such as AF processing in accordance with the control programs stored in the ROM while using the RAM as a work area.

Reference numerals 408 and 409 denote motors such as stepping motors for respectively moving the variator 502 and focus compensation lens 504. These motors 408 and 409 are respectively driven by motor drivers 410 and 411. Reference numeral 412 denotes an amplifier for amplifying the output signal from the photoelectric conversion element 402; and 413, a process circuit for converting the amplified signal into a video signal such as an NTSC video signal or the like.

Reference numeral 414 denotes an AF controller for generating a signal for auto-focusing (to be abbreviated as AF hereinafter) from the output signal of the process circuit 413, and controlling AF; and 415, a zooming unit.

- 5 The AF controller 414 uses the high-frequency component, edge shape, and the like of the video signal as in-focus information of an object, and determines the in-focus level based on the in-focus information. As the AF scheme, hill-climbing and the like have been proposed.
- 10 However, the basic principle of such AF scheme is known to those who are skilled in the art by, e.g., Japanese Patent Laid-Open No. 62-103616, and the like, and a detailed description thereof will be omitted. The zooming unit 315 outputs a signal indicating the zooming
- 15 direction (TELE or WIDE) and zooming speed. The zooming speed may be either a plurality of arbitrary speeds or a fixed speed.

- Fig. 21 shows cam loci that represent the positional relationship between the variator 502 that
- 20 changes the field angle and the focus compensation lens 504 that performs focus adjustment on the optical axis in the in-focus state. Upon zooming, the controller 407 drives the variator 502 and focus compensation lens 504 to trace one of these cam loci, thus preventing blurring.
- 25 However, since blur may be produced by movement of the object or initial selection errors of the cam locus, the

AF controller 414 operates to detect any blur.

In this case, the AF controller 414 samples a video signal generated by the process circuit 413 at the vertical scanning frequency of that video signal, and
5 determines the in-focus level on the basis of the high-frequency component and the like in the sampled video signal. The AF controller 414 compares the in-focus level obtained by the previous sampling with that
10 obtained at a sampling period (to be described later) to find a cam locus with higher in-focus level, and directs the controller 407 to switch the current cam locus to that with higher in-focus level.

The cam locus is selected without comparing the current and previous in-focus levels for the following
15 reason.

More specifically, when the current and previous in-focus levels are compared, in case of ultra-low-speed zooming, the in-focus level obtained by the current sampling may remain the same as that obtained by the
20 previous sampling in relation to the sampling period of an AF signal and the zooming speed. This example will be explained with reference to Fig. 22. Fig. 22 shows the relationship between the drive period of the variator
502 and AF signal when a stepping motor is used as a
25 drive motor for the variator 502, and the abscissa plots a sampling period (V) of the AF signal.

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If the zooming speed is expressed by, e.g., PPS (PPS: drive pulses of stepping motor + speed), when the variator 502 is driven at the sampling period of the AF signal, all AF signals can be reliably sampled when the variator 502 is driven (see "every V drive" in Fig. 22). However, when the AF signal (video signal) is sampled in synchronism with, e.g., the vertical scanning frequency (assume 60 Hz for NTSC) of a video signal generated by the process circuit 413, the variator 502 is

10 intermittently driven for sampling at a zooming speed less than 60 PPS. A curve indicated by "slow drive" in Fig. 22 indicates an AF signal when the zooming speed is 15 PPS. In this case, the variator 502 is driven once every time the AF signal is sampled four times, and the

15 AF signal changes.

In this case, since the variator 502 halts at three out of four sampling timings, the in-focus levels obtained at the previous and current sampling timings remain constant. For this reason, even when blurring has

20 occurred by tracing a non-in-focus locus shown in Fig. 2, switching to an in-focus locus cannot be made in time, or the control may halt in the blur state.

In order to solve such problem, the AF controller 414 determines the AF signal to be compared from those

25 obtained in previous "V"s by a calculation on the basis of the zooming speed and the sampling period of the AF

signal.

Cam locus trace during zooming will be explained below with reference to the flow chart in Fig. 23. Note that the processing in Fig. 23 repeats itself during
5 zooming.

It is checked based on a zoom drive command from the zooming unit 415 if the zooming mode is selected (step S201). If NO in step S201, the control ends. On the other hand, if YES in step S201, the zooming speed
10 signal from the zooming unit 415 is read (step S202). It is checked if the AF mode is set by an AF switch (not shown) (step S203). As a result, if NO in step S203, the cam locus is calculated on the basis of the zooming speed directed by the zooming unit 415 and the current
15 positions of the variator 502 and focus compensation lens 504, and a focus drive amount corresponding to the calculated cam locus is calculated (step S207). The cam locus calculation is done since only representative cam loci are stored, as shown in Fig. 21, and an
20 intermediate cam locus is obtained by a calculation to focus the lens with high precision using only a small volume of information.

On the other hand, if the AF mode is set, the sampling frequency of the AF signal is read (step S204),
25 and an AF signal to be used is determined from those obtained in previous "V"s (step S205) by:

$$PV = SV \div ZMSP \quad \dots(3)$$

where PV is the number of Vs to go back, SV is the sampling frequency of the AF signal, and ZMSP is the zooming speed. Note that PV is rounded up if the quotient has a remainder. Between the sampling period PV back obtained by equation (3), and the current sampling period, the variator 502 must have been driven. Also, the sampling period PV back is the one having a minimum interval from the current sampling period of those at which the variator 502 was driven.

Subsequently, the AF signal PV back calculated by equation (3) is compared with the current AF signal (step S206). A cam locus with higher in-focus level is selected, and a focus drive amount for tracing the selected cam locus is calculated on the basis of the zooming speed and the position of the variator 502 (step S207). The focus compensation lens 504 is driven by the calculated focus drive amount (step S208), thus ending the processing.

As described above, since the AF signal to be compared with the current AF signal is the one PV back calculated by equation (3), i.e., in the sampling period (V) in which the variator 502 was certainly driven, recognition errors of blur due to absence of AF signal changes can be prevented, and blur can be reliably detected to quickly change the cam locus.

(Ninth Embodiment)

Fig. 24 is a schematic block diagram showing the arrangement of an imaging apparatus according to the ninth embodiment of the present invention.

5 The imaging apparatus according to the ninth embodiment is of exchangeable lens type, and a camera unit controller 417 in a camera unit 440 transmits an AF control signal in a video signal generated by a process circuit 413, a stop control signal, an operation signal
10 from a zooming unit 415, and the like to a lens unit controller 416 in a lens unit 430 via a camera contact 419 and lens contact 418. The lens unit controller 416 controls AF and the stop on the basis of the signals transmitted from the camera unit controller 417, and
15 transmits the zoom position, focus position, stop position, and the like to the camera unit controller 417.

 An AF controller 414 in the lens unit controller 416 determines an AF signal to be compared with the current AF signal using equation (3) as in the AF
20 controller 414 of the eighth embodiment. Hence, the same effect as in the eighth embodiment can be obtained. When the AF controller 414 is mounted on the camera unit 440, the cost of the lens unit 430 can be reduced.

(10th Embodiment)

25 Fig. 25 is a schematic block diagram showing the arrangement of an imaging apparatus according to the

10th embodiment of the present invention. The imaging
apparatus of the 10th embodiment is also of exchangeable
lens type as in the ninth embodiment, and has
substantially the same arrangement and functions as
5 those of the ninth embodiment.

However, in the 10th embodiment, a format memory
420 for storing television formats such as NTSC, PAL,
and the like is added to the camera unit 440. The
television format stored in the format memory 420 is
10 transmitted to the AF controller 414 in the lens unit
430 via the camera contact 419 and lens contact 418. The
Af controller 414 detects the vertical scanning
frequency on the basis of the received television format,
and samples an AF signal at the detected vertical
15 scanning frequency. Also, the AF controller 414
determines the AF signal to be compared with the current
AF signal from those obtained in previous "V"s by a
calculation using the detected vertical scanning
frequency.

20 Cam locus trace during zooming according to the
10th embodiment will be explained below with reference
to the flow chart in Fig. 26. Note that the processing
in Fig. 26 repeats itself during zooming.

It is checked based on a zoom drive command from
25 the zooming unit 415 if the zooming mode is selected
(step S221). If NO in step S221, the control ends. On

the other hand, if YES in step S221, the zooming speed
 signal from the zooming unit 415 is read (step S222). It
 is checked if the AF mode is set by an AF switch (not
 shown) (step S223). As a result, if NO in step S223, the
 5 cam locus is calculated on the basis of the zooming
 speed directed by the zooming unit 415 and the current
 positions of the variator 502 and focus compensation
 lens 504, and a focus drive amount corresponding to the
 calculated cam locus is calculated (step S227). The cam
 10 locus calculation is done since only representative cam
 loci are stored, as shown in Fig. 21, and an
 intermediate cam locus is obtained by a calculation to
 focus the lens with high precision using only a small
 volume of information.

15 On the other hand, if the AF mode is set, camera
 data (television format) is read from the camera unit
 440 via a communication to detect its vertical scanning
 frequency, and the AF signal is sampled in synchronism
 with the detected vertical scanning frequency (step
 20 S224). Then, an AF signal to be used is determined from
 those obtained in previous "V"s (step S225). When the
 television format is NTSC, equation (4) below is used;
 if it is PAL, equation (5) below is used.

$$PV = NV \div ZMSP \quad \dots(4)$$

25 where NV is the vertical scanning frequency of the NTSC
 television format

$$PV = PaV \div ZMSP \quad \dots(5)$$

where PaV is the vertical scanning frequency of the PAL television format.

Note that PV is rounded up if the quotient has a remainder. Between the sampling period PV back obtained by equation (4) or (5), and the current sampling period, the variator 502 must have been driven. Also, the sampling period PV back is the one having a minimum interval from the current sampling period of those in which the variator 502 was driven.

Subsequently, the AF signal PV back calculated by equation (4) or (5) is compared with the current AF signal (step S226). A cam locus with higher in-focus level is selected, and a focus drive amount for tracing the selected cam locus is calculated on the basis of the zooming speed and the position of the variator 502 (step S227). The focus compensation lens 504 is driven by the calculated focus drive amount (step S228), thus ending the processing.

In this manner, since the frequency to be used as the sampling frequency of the AF signal is detected on the basis of television format information transmitted from the camera unit 440, the lens unit 430 as an exchangeable lens can be used together with camera units 440 of different television formats, thus improving compatibility.

Note that the present invention is not limited to the eighth to 10th embodiments. For example, in place of the television format, the vertical scanning frequency itself of that television format may be transmitted.

5 Also, in place of selecting a cam locus by comparing the in-focus level several periods before with the current in-focus level, if the zooming speed is low, the sampling frequency itself may be decreased to prolong the sampling period, and a cam locus may be selected by
10 always comparing the current and previous in-focus levels. Furthermore, these embodiments can be applied to a case wherein the variator and focus compensation lens are driven by motors which rotate continuously.

To restate, according to the eighth to 10th
15 embodiments, in an imaging apparatus which comprises a lens system including a zoom lens group for changing the field angle and a focus compensation lens group having both a function of correcting changes in focal plane position upon movement of the zoom lens group and a
20 focus adjustment function, and storage means for storing a locus representing the positional relationship between the zoom lens group and focus compensation lens group in an in-focus state in correspondence with the object distance, and moves the zoom lens group and focus
25 compensation lens group to trace the stored locus upon zooming, a video signal is generated by

photoelectrically converting an optical image obtained from the lens system, the focus states are detected upon zooming from the generated video signal at a predetermined period and are compared to determine the in-focus level and a direction to drive to reach an in-focus point, and the period is determined on the basis of the moving speed of the zoom lens group.

Hence, recognition errors of deterioration of the in-focus level due to absence of in-focus level changes, although blurring has occurred in practice, can be prevented irrespective of the zooming speed, and deterioration of the in-focus level can be reliably detected to quickly change the cam locus.

(11th Embodiment)

Fig. 27 shows the 11th embodiment of the present invention. In this embodiment, a cam locus selector 450 is added to the imaging apparatus of the eighth embodiment shown in Fig. 20.

Referring to Fig. 27, reference numeral 450 denotes a cam locus selector for selecting an optimal cam locus that can remove blur produced during zooming. The cam locus selector 450 selects a cam locus on the basis of the zooming speed, and the blur detection level (in-focus level) informed from the AF controller 414. Note that the cam locus is selected by determining the drive amount (to be referred to as a focus drive amount

hereinafter) of the focus compensation lens 504 in practice.

Upon selecting a cam locus on the basis of the zooming speed and blur detection level, the cam locus selector 450 sets a large focus drive amount when the zooming speed is low and blur is large, as shown in Fig. 28. On the other hand, the selector 450 sets a small focus drive amount when the zooming speed is high and blur is small. That is, the focus drive amount is determined in inverse proportion to the in-focus level and zooming speed.

In this embodiment, in practice, an optimal cam locus that can remove blur, i.e., the focus drive amount is given by:

$$AFP = AFD \times FK \quad \dots (6)$$

where AFP is the focus drive amount based on the blur detection level, FK is a calculation coefficient obtained from the zooming speed and blur detection level, and AFD is the unit focus drive amount upon detection of blur.

The unit focus drive amount AFD takes the focal length, stop, focus position, and the like into consideration, and is obtained by calculation in correspondence with the focal length, stop, focus position, and the like. That is, the amount AFD varies if the focal length, stop, focus position, and the like

vary. In this case, the focus drive amount corresponding to the focal length, stop, focus position, and the like may be stored in the form of a table, and may be read out as needed.

5 The calculation coefficient FK limits the focus drive amount to be proportional to blur (i.e., inverse proportional to in-focus level) and to be inversely proportional to the zooming speed, as shown in Fig. 29. The calculation coefficient FK may be obtained using a
10 predetermined formula on the basis of the zooming speed and blur detection level, or the moving distance of the focus compensation lens group 504 corresponding to the blur detection level and zooming speed may be stored in the form of table and a calculation coefficient
15 corresponding to the zooming speed and blur detection level may be read out as needed. The calculation coefficient FK is preferably stored in a rewritable storage medium since it can be arbitrarily changed.

 The calculation coefficient FK may change the focus
20 drive amount stepwise, as shown in Fig. 28, or continuously, as shown in Fig. 29. Furthermore, when a calculation coefficient FK that changes stepwise is used, the change step of the focus drive amount may be smaller than that in Fig. 28.

25 Focusing during zooming will be explained below with reference to the flow chart in Fig. 30. Note that

the processing in Fig. 30 repeats itself during zooming.

It is checked based on a zoom drive command from the zooming unit 415 if the zooming mode is selected (step S311). If NO in step S311, the control ends. On the other hand, if YES in step S311, the zooming speed signal from the zooming unit 415 is read (step S312). The cam locus is calculated on the basis of the zooming speed and the current positions of the variator 502 and focus compensation lens 504, and a focus drive amount corresponding to the calculated cam locus is calculated (step S313). The cam locus calculation is done since only representative cam loci are stored, as shown in Fig. 21, and an intermediate cam locus is obtained by a calculation to focus the lens with high precision using only a small volume of information.

It is checked if the AF mode is set by an AF switch (not shown) (step S314). As a result, if NO in step S314, the focus compensation lens 504 is driven by the focus drive amount calculated in step S313 (step S320), thus ending the processing. On the other hand, if the AF mode is set, the AF controller 414 executes in-focus level determination to detect any blur (step S315), and it is then checked if blur is detected (step S316). As a result, if no blur is detected, the focus compensation lens 504 is driven by the focus drive amount calculated in step S313 (step S320), thus ending the processing.

On the other hand, if blur is detected, the calculation coefficient FK corresponding to the blur level (in-focus level) and zooming speed is calculated (step S317). A focus drive amount corresponding to the blur level (in-focus level) and zooming speed is calculated by equation (6) above using the calculated calculation coefficient FK (step S318). Then, the focus drive amount corresponding to the cam locus calculated in step S313, and that corresponding to the blur level (in-focus level) and zooming speed calculated in step S318 are added to each other (step S319). The focus compensation lens 504 is then driven by the sum focus drive amount calculated in step S313 (step S320), thus ending the processing.

In this manner, when the focus compensation lens 504 is driven by the sum focus drive amount, the cam locus can be switched from that selected in step S313 to a cam locus at a position separated by the focus drive amount calculated in step S318 (note that the locus is not switched, and the initially calculated focus drive amount may be merely corrected in some cases). In this case, when the zooming speed is low and blur is large (i.e., the in-focus level is low), the cam locus is switched to the one at a position separated from the currently selected cam locus; when the zooming speed is high and blur is small (the in-focus level is high), the

cam locus is switched to the one at a position near the currently selected cam locus.

Therefore, when the cam locus is switched, the control can be prevented from overshooting an in-focus cam locus to be selected and generating blur upon ultra-high-speed zooming. Also, upon ultra-low-speed zooming, an in-focus cam locus can be quickly reached. That is, the focus moving amount upon blurring during zooming can be quickly corrected with high precision independently of the zooming speed.

(12th Embodiment)

Fig. 31 is a schematic block diagram showing the arrangement of an imaging apparatus according to the 12th embodiment of the present invention.

The imaging apparatus according to the 12th embodiment is of exchangeable lens type, and a camera unit controller 417 in a camera unit 440 transmits an AF control signal in a video signal generated by a process circuit 413, a stop control signal, an operation signal from a zooming unit 415, and the like to a lens unit controller 416 in a lens unit 430 via a camera contact 419 and lens contact 418. The lens unit controller 416 controls AF and the stop on the basis of the signals transmitted from the camera unit controller 417, and transmits the zoom position, focus position, stop position, and the like to the camera unit controller 417.

The lens unit controller 416 includes an AF controller 414 and cam locus selector 450 as in the controller 407 of the 11th embodiment. When blur is detected during zooming, the cam locus is switched in consideration of the blur level and zooming speed, as in the 11th embodiment. Therefore, the same effect as in the 11th embodiment can be expected. Note that the AF controller 414 and cam locus selector 450 may be mounted on the camera unit 440 to reduce the cost of the lens unit 430.

Note that the present invention is not limited to the 11th and 12th embodiments described above. For example, the focus moving amount may be corrected based on the zooming speed alone.

Also, a locus may be selected based on the position information of the zoom lens and focus lens, the moving amount of the focus lens for tracing the selected locus may be calculated on the basis of the in-focus level, and the calculated moving amount of the focus lens may be changed in correspondence with the moving speed of the zoom lens.

Furthermore, a locus may be selected in correspondence with the position information of the zoom lens and focus lens, in-focus level, and moving speed of the zoom lens and the moving amount of the focus lens for tracing the locus may be controlled. In these cases,

a larger focus lens moving amount is set with decreasing in-focus level, and a smaller focus lens moving amount is set with increasing moving speed of the zoom lens.

To recapitulate, according to the 11th and 12th
5 embodiments, an imaging apparatus which comprises a lens system including a zoom lens group for changing the field angle and a focus compensation lens group having both a function of correcting changes in focal plane position upon movement of the zoom lens group and a
10 focus adjustment function, and storage means for storing a locus representing the positional relationship between the zoom lens group and focus compensation lens group in an in-focus state in correspondence with the object distance, and moves the zoom lens group and focus
15 compensation lens group to trace the stored locus upon zooming, comprises selection means for selecting the locus on the basis of positions of the zoom lens group and focus compensation lens group, detection means for detecting the in-focus level, and control means for
20 determining the moving amount of the focus compensation lens on the basis of the selected locus information, the in-focus level detected by the detection means upon zooming, and the moving speed of the zoom lens group. Therefore, the focus moving amount upon production of
25 blur during zooming can be quickly corrected with high precision irrespective of the zooming speed.

WHAT IS CLAIMED IS:

1. An optical equipment for forming an object image on a predetermined plane via an optical system including a movable lens that moves along an optical axis,

5 comprising:

lens drive means for driving said movable lens;

first storage means for storing control information for controlling a position of said movable lens;

second storage means for storing correction data
10 for correcting the control data stored in said first storage means; and

control means for controlling said lens drive means on the basis of the control information in said first storage means and the correction data in said second
15 storage means.

2. The equipment according to claim 1, further comprising selection means for selecting whether or not said control means uses the correction data in said second storage means.

20 3. The equipment according to claim 1, wherein said second storage means comprises a rewritable storage device.

4. The equipment according to claim 1, wherein the correction data is difference information between
25 theoretical control information and true control information.

5. The equipment according to claim 1, further comprising imaging means for forming the object image.

6. The equipment according to claim 1, further comprising:

5 a camera unit having imaging means for forming the object image; and

a lens unit having said control means and detachably connected to said camera unit.

7. A computer-readable storage medium storing a
10 program for executing a sequence for controlling driving of a movable lens using control information for controlling a position of said movable lens and correction data for correcting the control information.

8. The medium according to claim 7, further storing a
15 program for executing a sequence for selecting whether or not the correction data is used.

9. The medium according to claim 7, wherein the correction data is difference information between theoretical control information for controlling a
20 position of a movable lens, and true control information.

10. A computer-readable storage medium storing difference information between theoretical control information for controlling a position of a movable lens, and true control information.

25 11. A lens apparatus comprising:

movable lens means for forming an object image on a

predetermined plane while moving along an optical axis;

drive means for driving said movable lens means;

connection means for detachably attaching an
external device;

5 detection means for detecting attachment/detachment
of said external device;

first storage means for storing first control
information for controlling a position of said movable
lens means when said external device is attached;

10 second storage means for storing second control
information for controlling the position of said movable
lens means when said external device is not attached;
and

control means for reading out contents of said
15 first or second storage means in accordance with a
detection result of said detection means, and
controlling said drive means using the first or second
control information.

12. A lens apparatus comprising:

20 movable lens means for forming an object image on a
predetermined plane while moving along an optical axis;

drive means for driving said movable lens means;

connection means for detachably attaching an
external device;

25 detection means for detecting attachment/detachment
of said external device;

first storage means for storing control information
for controlling a position of said movable lens means
when said external device is attached;

second storage means for storing correction data
5 for correcting the control information; and

control means for reading out contents of said
first and/or second storage means in accordance with a
detection result of said detection means, and
controlling said drive means using the control
10 information when said external device is not attached or
using control information obtained by correcting the
control information by the correction data when said
external device is attached.

13. The apparatus according to claim 12, further
15 comprising selection means for selecting whether or not
said control means uses the correction data when said
external device is attached.

14. The apparatus according to claim 12, wherein said
external device has a zoom lens, and the correction data
20 is difference information between the control
information and control information required when said
external device is attached.

15. The apparatus according to claim 12, wherein said
external device has a zoom lens.

25 16. The apparatus according to claim 12, wherein said
second storage means comprises a rewritable storage

device.

17. The apparatus according to claim 12, wherein said external device comprises an extender for changing a focal length of a lens.

5 18. The apparatus according to claim 17, wherein said first storage means stores lens moving locus information for correcting a focal plane position which changes upon zooming, when said extender is attached.

10 19. The apparatus according to claim 18, wherein said second storage means stores lens moving locus information for correcting a focal plane position which changes upon zooming, when said extender is not attached.

20. A computer-readable storage medium storing a program for executing:

15 a sequence of detecting if an external device is attached; and

a sequence of controlling a position of a movable lens using first control information when it is detected that the external device is not attached, and

20 controlling the position of the movable lens using second control information when it is detected that the external device is attached.

21. A computer-readable storage medium storing a program for executing:

25 a sequence of detecting if an external device is attached; and

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a sequence of controlling a position of a movable lens using control information when it is detected that the external device is not attached, and controlling the position of the movable lens using control information
5 obtained by correcting the control information by correction data when it is detected that the external device is attached.

22. A computer-readable storage medium storing correction data for correcting control information that
10 controls a position of a movable lens when an external device is attached to a lens apparatus having a movable lens.

23. A computer-readable storage medium storing correction data for correcting control information that
15 controls a position of a movable lens when an external apparatus is attached to a lens apparatus having the movable lens.

24. An imaging apparatus which has a lens system including a zoom lens group for changing a field angle
20 and a focus compensation lens group having both a function of correcting a change in focal plane position upon movement of said zoom lens group and a focus adjustment function, and storage means for storing a locus that represents a positional relationship between
25 said zoom lens group and focus compensation lens group in an in-focus state in correspondence with an object

distance, and moves said zoom lens group and focus compensation lens group to trace the locus stored in said storage means upon zooming, comprising:

generation means for generating a video signal by
5 photoelectrically converting an optical image obtained via said lens system;

discrimination means for discriminating an in-focus level and a direction to drive to reach an in-focus point by detecting focus states at a predetermined
10 period from the video signal generated by said generation means and comparing the focus states upon zooming; and

determination means for determining the period on the basis of a moving speed of said zoom lens group.
15 25. The apparatus according to claim 24, wherein said determination means divides a period of processing for detecting the focus state by the moving speed of said zoom lens group to obtain a quotient, and determines an in-focus level extracted in an extraction period n
20 extraction periods back ($n = \text{the quotient}$) as an in-focus level to be compared with the currently discriminated in-focus level.

26. The apparatus according to claim 24, wherein said lens system comprises an exchangeable lens system.

25 27. The apparatus according to claim 24, wherein said lens system comprises an exchangeable lens system, and

said discrimination means detects a vertical scanning period of the video signal generated by said generation means, which is mounted on an imaging apparatus main body, on the basis of television format information
 5 obtained from the imaging apparatus main body via a communication.

28. The apparatus according to claim 24, wherein said lens system comprises an exchangeable lens system, and said discrimination means obtains a vertical scanning
 10 period of the video signal generated by said generation means, which is mounted on an imaging apparatus main body, via a communication.

29. The apparatus according to claim 24, wherein driving of said zoom lens group and focus compensation
 15 lens group is controlled by a stepping motor.

30. An imaging method for an imaging apparatus which has a lens system including a zoom lens group for changing a field angle and a focus compensation lens group having both a function of correcting a change in
 20 focal plane position upon movement of said zoom lens group and a focus adjustment function, and storage means for storing a locus that represents a positional relationship between said zoom lens group and focus compensation lens group in an in-focus state in
 25 correspondence with an object distance, and moves said zoom lens group and focus compensation lens group to

trace the locus stored in said storage means upon
zooming, comprising:

the generation step of generating a video signal by
photoelectrically converting an optical image obtained
5 via said lens system;

the discrimination step of discriminating an in-
focus level and a direction to drive to reach an in-
focus point by detecting focus states at a predetermined
period from the video signal generated in the generation
10 step and comparing the focus states upon zooming; and

the determination step of determining the period on
the basis of a moving speed of said zoom lens group.

31. The method according to claim 30, wherein the
determination step includes the step of dividing a
15 period of processing for detecting the focus state by
the moving speed of said zoom lens group to obtain a
quotient, and determining an in-focus level extracted in
an extraction period n extraction periods back ($n =$ the
quotient) as an in-focus level to be compared with the
20 currently discriminated in-focus level.

32. The method according to claim 30, wherein said lens
system comprises an exchangeable lens system.

33. The method according to claim 30, wherein said lens
system comprises an exchangeable lens system, and the
25 discrimination step includes the step of detecting a
vertical scanning period of the video signal generated

in the generation step, which is installed on an imaging apparatus main body, on the basis of television format information obtained from the imaging apparatus main body via a communication.

5 34. The method according to claim 30, wherein said lens system comprises an exchangeable lens system, and the discrimination step includes the step of obtaining a vertical scanning period of the video signal generated in the generation step, which is installed on an imaging
10 apparatus main body, via a communication.

35. The method according to claim 30, wherein driving of said zoom lens group and focus compensation lens group is controlled by a stepping motor.

36. A storage medium which is used in an imaging
15 apparatus having a lens system including a zoom lens group for changing a field angle and a focus compensation lens group having both a function of correcting a change in focal plane position upon movement of said zoom lens group and a focus adjustment
20 function, and storage means for storing a locus that represents a positional relationship between said zoom lens group and focus compensation lens group in an in-focus state in correspondence with an object distance, and which stores a program for moving said zoom lens
25 group and focus compensation lens group to trace the locus stored in said storage means upon zooming, said

program stored in said storage medium including:

a generation routine for generating a video signal by photoelectrically converting an optical image obtained via said lens system;

5 a discrimination routine for discriminating an in-focus level and a direction to drive to reach an in-focus point by detecting focus states at a predetermined period from the video signal generated in the generation routine and comparing the focus states upon zooming; and

10 a determination routine for determining the period on the basis of a moving speed of said zoom lens group.

37. The medium according to claim 36, wherein the determination routine includes a routine for dividing a period of processing for detecting the focus state by
15 the moving speed of said zoom lens group to obtain a quotient, and determining an in-focus level extracted in an extraction period n extraction periods back (n = the quotient) as an in-focus level to be compared with the currently discriminated in-focus level.

20 38. The medium according to claim 36, wherein said lens system comprises an exchangeable lens system.

39. The medium according to claim 36, wherein said lens system comprises an exchangeable lens system, and the discrimination routine includes the routine for
25 detecting a vertical scanning period of the video signal generated in the generation routine, which is installed

on an imaging apparatus main body, on the basis of television format information obtained from the imaging apparatus main body via a communication.

40. The medium according to claim 36, wherein said lens system comprises an exchangeable lens system, and the discrimination routine includes a routine for obtaining a vertical scanning period of the video signal generated in the generation routine, which is installed on an imaging apparatus main body, via a communication.

41. The medium according to claim 36, wherein driving of said zoom lens group and focus compensation lens group is controlled by a stepping motor.

42. A lens control apparatus comprising:

a zoom lens;

a focus lens;

focus detection means for detecting a focus state from a video signal at a predetermined period;

focus control means for controlling said focus lens on the basis of an output from said focus detection

means; and

control means for changing the period on the basis of a moving speed of said zoom lens.

43. The apparatus according to claim 42, wherein said focus detection means normally detects the focus state at a period of a vertical synchronization signal, and said control means controls to prolong the period when

the moving speed of said zoom lens is low.

44. A lens control method comprising:

the focus detection step of detecting a focus state
from a video signal at a predetermined period in an

5 imaging apparatus having a zoom lens and focus lens;

the focus control step of controlling said focus
lens on the basis of an output from the focus detection
step; and

the control step of changing the period on the
10 basis of a moving speed of said zoom lens.

45. The method according to claim 44, wherein the focus
detection step includes the step of normally detecting
the focus state at a period of a vertical

synchronization signal, and the control step includes
15 the step of controlling to prolong the period when the
moving speed of said zoom lens is low.

46. An imaging apparatus which has a lens system

including a zoom lens group for changing a field angle
and a focus compensation lens group having both a

20 function of correcting a change in focal plane position
upon movement of said zoom lens group and a focus

adjustment function, and storage means for storing a
locus that represents a positional relationship between
said zoom lens group and focus compensation lens group

25 in an in-focus state in correspondence with an object
distance, and moves said zoom lens group and focus

compensation lens group to trace the locus stored in
said storage means upon zooming, comprising:

selection means for selecting the locus on the
basis of positions of said zoom lens group and focus

5 compensation lens group;

detection means for detecting an in-focus level;

and

control means for determining a moving amount of
said focus compensation lens group on the basis of the
10 selected locus information, the in-focus level detected
by said detection means upon zooming, and a moving speed
of said zoom lens group.

47. The apparatus according to claim 46, wherein said
control means controls the moving amount of said focus
15 compensation lens to be inversely proportional to the
in-focus level and the moving speed of said zoom lens
group.

48. The apparatus according to claim 46, wherein said
control means selects a new locus from the locus
20 selected by said selection means by calculation
processing.

49. The apparatus according to claim 46, wherein said
control means has storage means for storing the moving
amount of the focus compensation lens group
25 corresponding to the in-focus level and the moving speed
of said zoom lens group as information for selecting a

new locus.

50. The apparatus according to claim 46, wherein said control means selects a new locus to change the moving amount of said focus compensation lens group stepwise in
5 correspondence with the in-focus level and the moving speed of said zoom lens group.

51. The apparatus according to claim 46, wherein said control means selects a new locus to change the moving amount of said focus compensation lens group
10 continuously in correspondence with the in-focus level and the moving speed of said zoom lens group.

52. The apparatus according to claim 46, wherein said lens system comprises an exchangeable lens system, and said detection means and control means are mounted on
15 said exchangeable lens system.

53. The apparatus according to claim 46, wherein said lens system comprises an exchangeable lens system, and said detection means and control means are mounted on an imaging apparatus main body.

20 54. An imaging method for an imaging apparatus which has a lens system including a zoom lens group for changing a field angle and a focus compensation lens group having both a function of correcting a change in focal plane position upon movement of said zoom lens
25 group and a focus adjustment function, and storage means for storing a locus that represents a positional

relationship between said zoom lens group and focus
compensation lens group in an in-focus state in
correspondence with an object distance, and moves said
zoom lens group and focus compensation lens group to
5 trace the locus stored in said storage means upon
zooming, comprising:

the selection step of selecting the locus on the
basis of positions of said zoom lens group and focus
compensation lens group;

10 the detection step of detecting an in-focus level;
and

the control step of determining a moving amount of
said focus compensation lens group on the basis of the
selected locus information, the in-focus level detected
15 in the detection step upon zooming, and a moving speed
of said zoom lens group.

55. The method according to claim 54, wherein the
control step includes the step of controlling the moving
amount of said focus compensation lens to be inversely
20 proportional to the in-focus level and the moving speed
of said zoom lens group.

56. The method according to claim 54, wherein the
control step includes the step of selecting a new locus
from the locus selected in the selection step by
25 calculation processing.

57. The method according to claim 54, wherein the

control step has the storage step of storing the moving
amount of the focus compensation lens group
corresponding to the in-focus level and the moving speed
of said zoom lens group as information for selecting a
5 new locus.

58. The method according to claim 54, wherein the
control step includes the step of selecting a new locus
to change the moving amount of said focus compensation
lens group stepwise in correspondence with the in-focus
10 level and the moving speed of said zoom lens group.

59. The method according to claim 54, wherein the
control step includes the step of selecting a new locus
to change the moving amount of said focus compensation
lens group continuously in correspondence with the in-
15 focus level and the moving speed of said zoom lens group.

60. The method according to claim 54, wherein said lens
system comprises an exchangeable lens system, and the
detection step and control step are installed on said
exchangeable lens system.

20 61. The method according to claim 54, wherein said lens
system comprises an exchangeable lens system, and the
detection step and control step are installed on an
imaging apparatus main body.

62. A storage medium which is used in an imaging
25 apparatus having a lens system including a zoom lens
group for changing a field angle and a focus

compensation lens group having both a function of
correcting a change in focal plane position upon
movement of said zoom lens group and a focus adjustment
function, and storage means for storing a locus that
5 represents a positional relationship between said zoom
lens group and focus compensation lens group in an in-
focus state in correspondence with an object distance,
and which stores a program for moving said zoom lens
group and focus compensation lens group to trace the
10 locus stored in said storage means upon zooming, said
program including:

a selection routine for selecting the locus on the
basis of positions of said zoom lens group and focus
compensation lens group;

15 a detection routine for detecting an in-focus
level; and

a control routine for determining a moving amount
of said focus compensation lens group on the basis of
the selected locus information, the in-focus level
20 detected in the detection routine upon zooming, and a
moving speed of said zoom lens group.

63. The medium according to claim 62, wherein the
control routine includes a routine for controlling the
moving amount of said focus compensation lens to be
25 inversely proportional to the in-focus level and the
moving speed of said zoom lens group.

5 65. The medium according to claim 62, wherein the
control routine has a storage routine for storing the
moving amount of the focus compensation lens group
corresponding to the in-focus level and the moving speed
of said zoom lens group as information for selecting a
10 new locus.

66. The medium according to claim 62, wherein the control routine includes a routine for selecting a new locus to change the moving amount of said focus compensation lens group stepwise in correspondence with the in-focus level and the moving speed of said zoom lens group.

67. The medium according to claim 62, wherein the control routine includes a routine for selecting a new locus to change the moving amount of said focus compensation lens group continuously in correspondence with the in-focus level and the moving speed of said zoom lens group.

68. The medium according to claim 62, wherein said lens system comprises an exchangeable lens system, and the detection routine and control routine are executed by
25 said exchangeable lens system.

69. The medium according to claim 62, wherein said lens system comprises an exchangeable lens system, and the detection routine and control routine are executed by an imaging apparatus main body.

5 70. A lens control apparatus comprising:

a zoom lens;

a focus lens having a function of correcting a change in focal plane position upon movement of said zoom lens;

10 storage means for storing a locus representing a positional relationship between said zoom lens and focus lens in an in-focus state in correspondence with an object distance;

detection means for detecting an in-focus level;

15 selection means for selecting the locus on the basis of position information of said zoom lens and focus lens; and

control means for calculating a moving amount of said focus lens to move said focus lens according to the locus on the basis of the locus information selected by said selection means and the in-focus level detected by said detection means, and changing the moving amount of said focus lens in correspondence with a moving speed of said zoom lens.

25 71. The apparatus according to claim 70, wherein said control means changes the moving amount of said focus

lens in correspondence with the moving speed of said zoom lens, and controls to decrease the moving amount of said focus lens as the moving speed of said zoom lens is higher.

5 72. The apparatus according to claim 70, wherein said control means controls to increase the moving amount of said focus lens as the in-focus level detected by said detection means is lower, and to decrease the moving amount of said focus lens as the moving speed of said zoom lens is higher.

10 73. A lens control apparatus comprising:
a zoom lens;
a focus lens having a function of correcting a change in focal plane position upon movement of said zoom lens;
15 storage means for storing a locus representing a positional relationship between said zoom lens and focus lens in an in-focus state in correspondence with an object distance;
20 detection means for detecting an in-focus level;
and
control means for selecting the locus in accordance with position information of said zoom lens and focus lens, the in-focus level detected by said detection means, and a moving speed of said zoom lens, and
25 controlling a moving amount which makes said focus lens

trace the locus.

74. The apparatus according to claim 73, wherein said control means changes the moving amount of said focus lens in correspondence with the moving speed of said zoom lens, and controls to decrease the moving amount of said focus lens as the moving speed of said zoom lens is higher.

75. The apparatus according to claim 73, wherein said control means controls to increase the moving amount of said focus lens as the in-focus level detected by said detection means is lower, and to decrease the moving amount of said focus lens as the moving speed of said zoom lens is higher.

ABSTRACT OF THE DISCLOSURE

The object of this invention is to attain accurate control by correcting any deviation of a cam locus due
5 to manufacturing errors and the like upon controlling a zoom lens and focus lens along a theoretical cam locus. To attain this object, a differential locus between the theoretical cam locus (stored cam locus) and a true cam locus due to an error obtained by a measurement is
10 obtained, and is stored as cam correction data. The lens control is made while correcting the theoretical cam locus by the correction data.

FIG.1

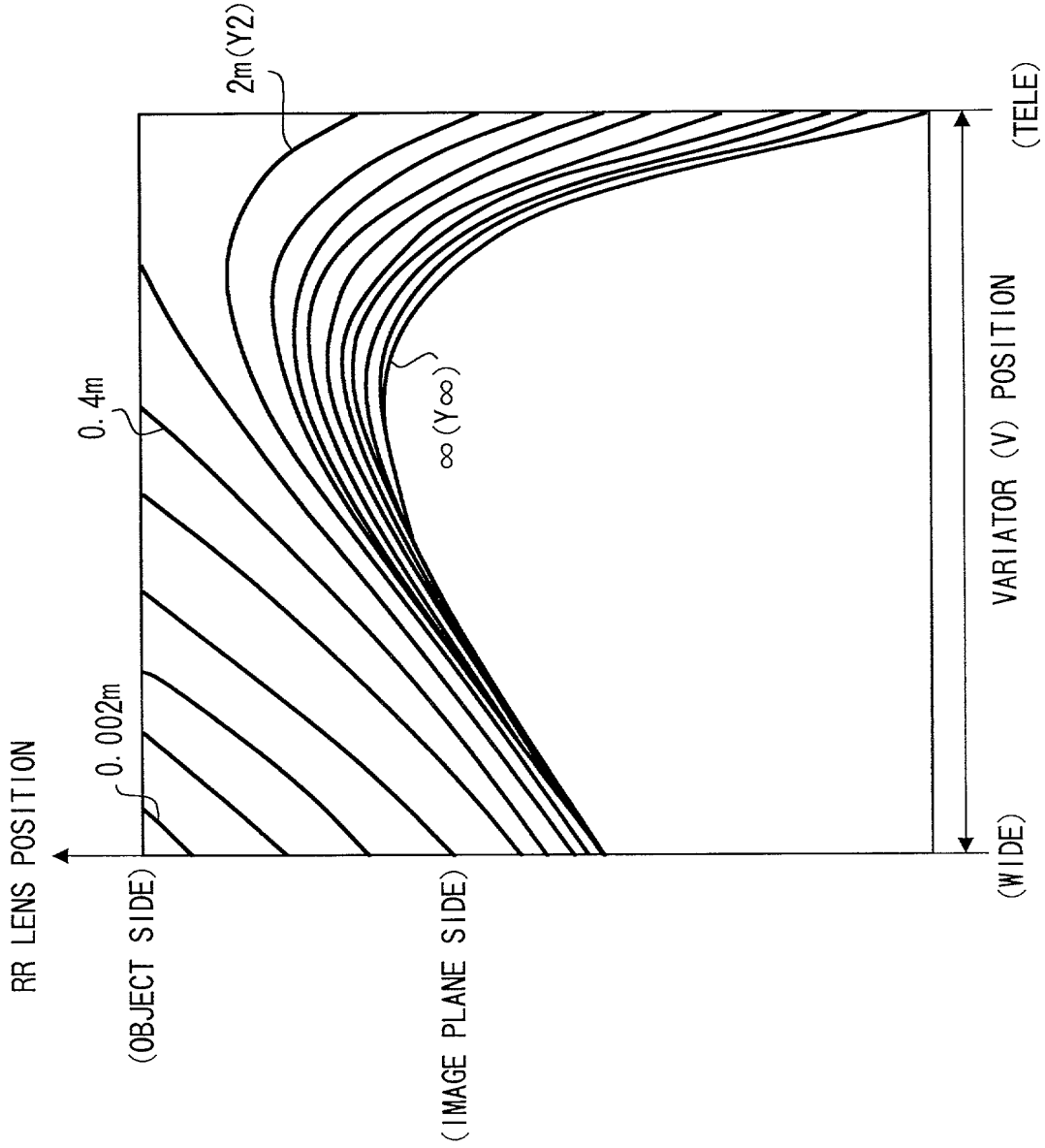


FIG.2

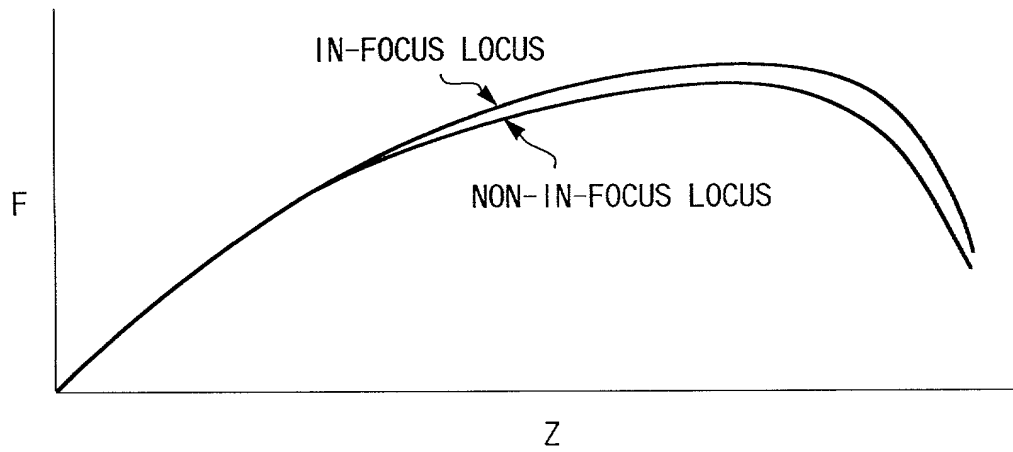


FIG.3

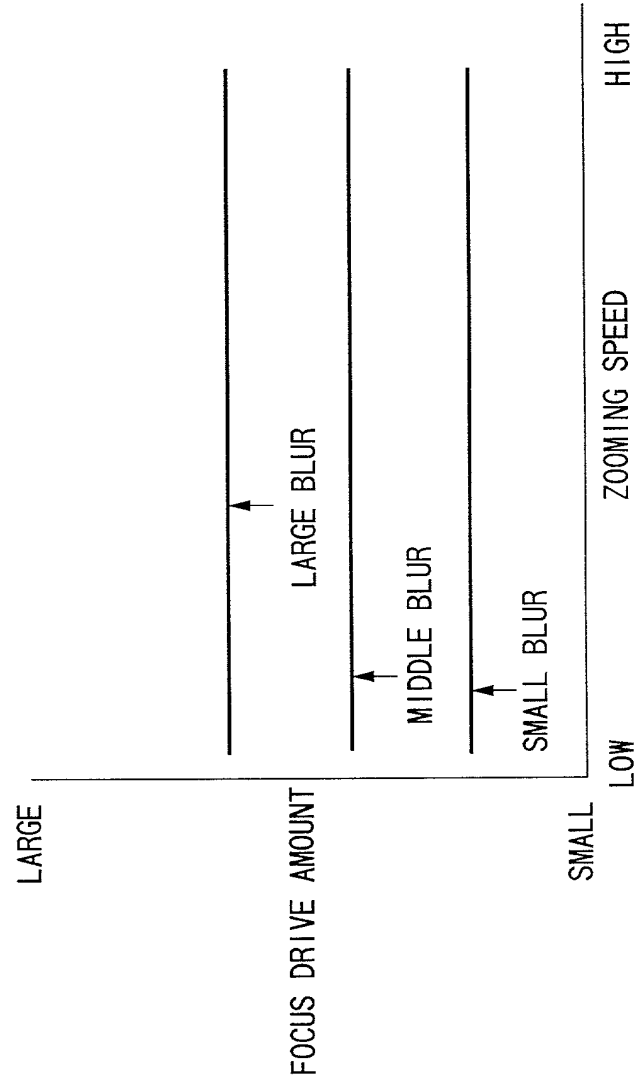


FIG.4

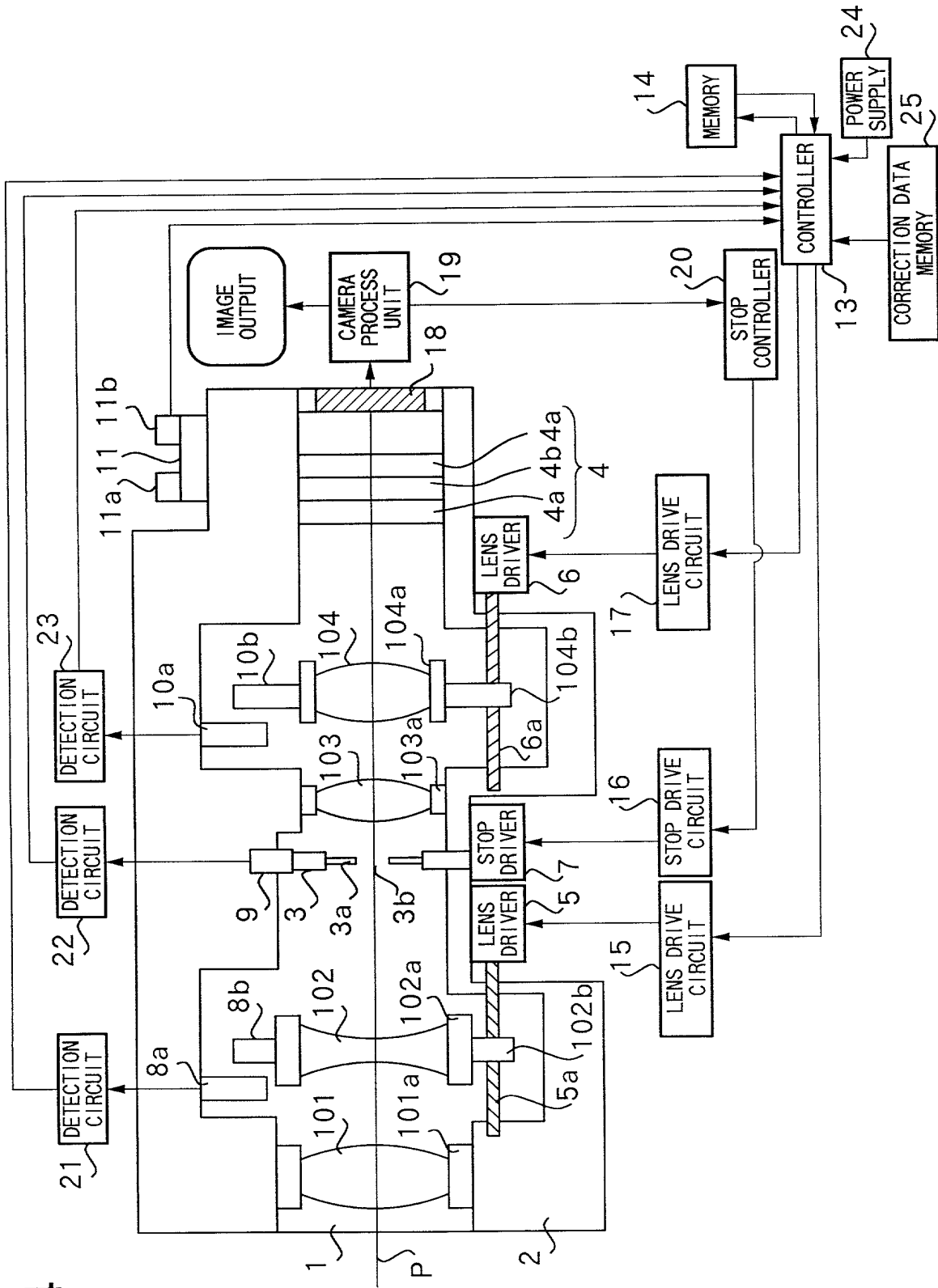


FIG.5

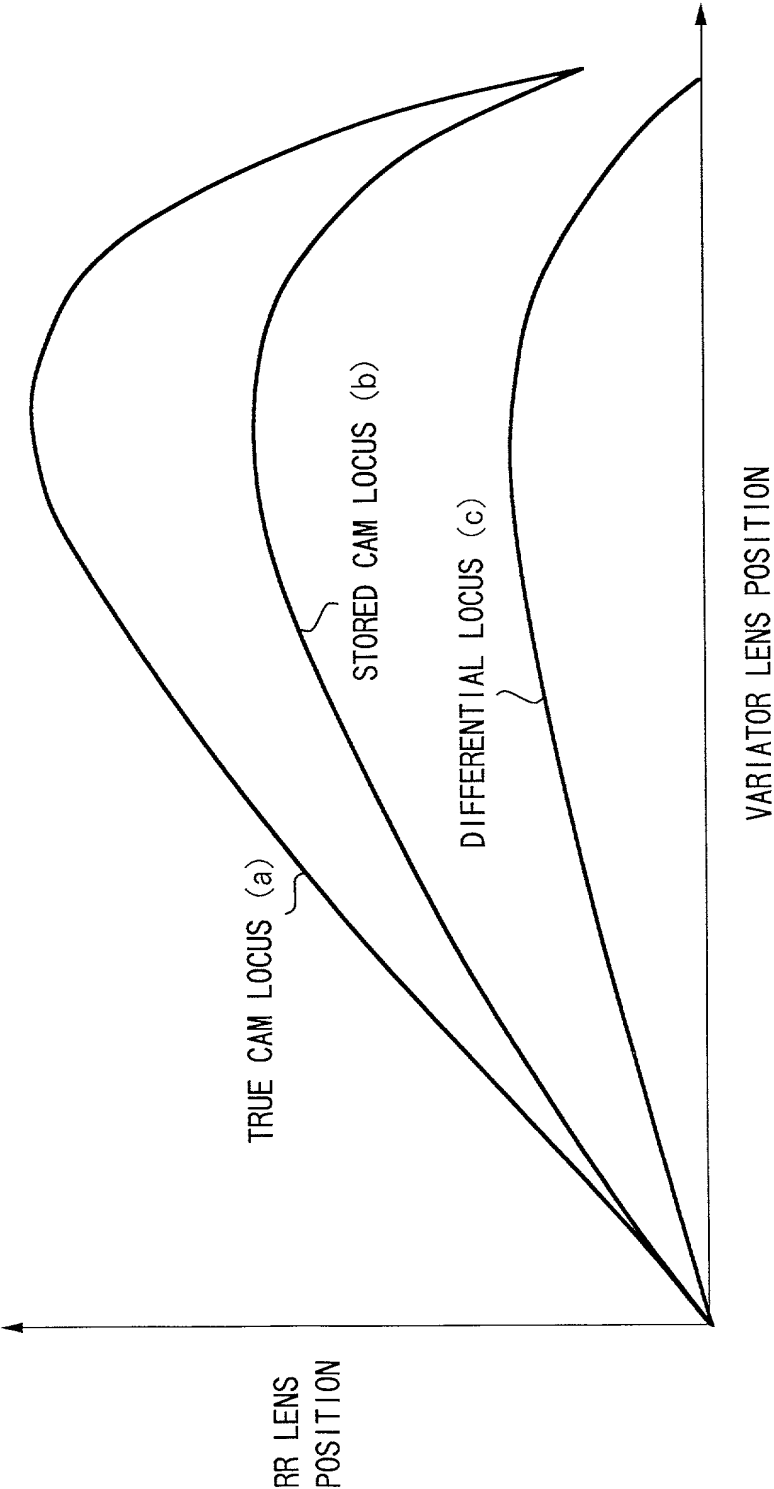


FIG.6

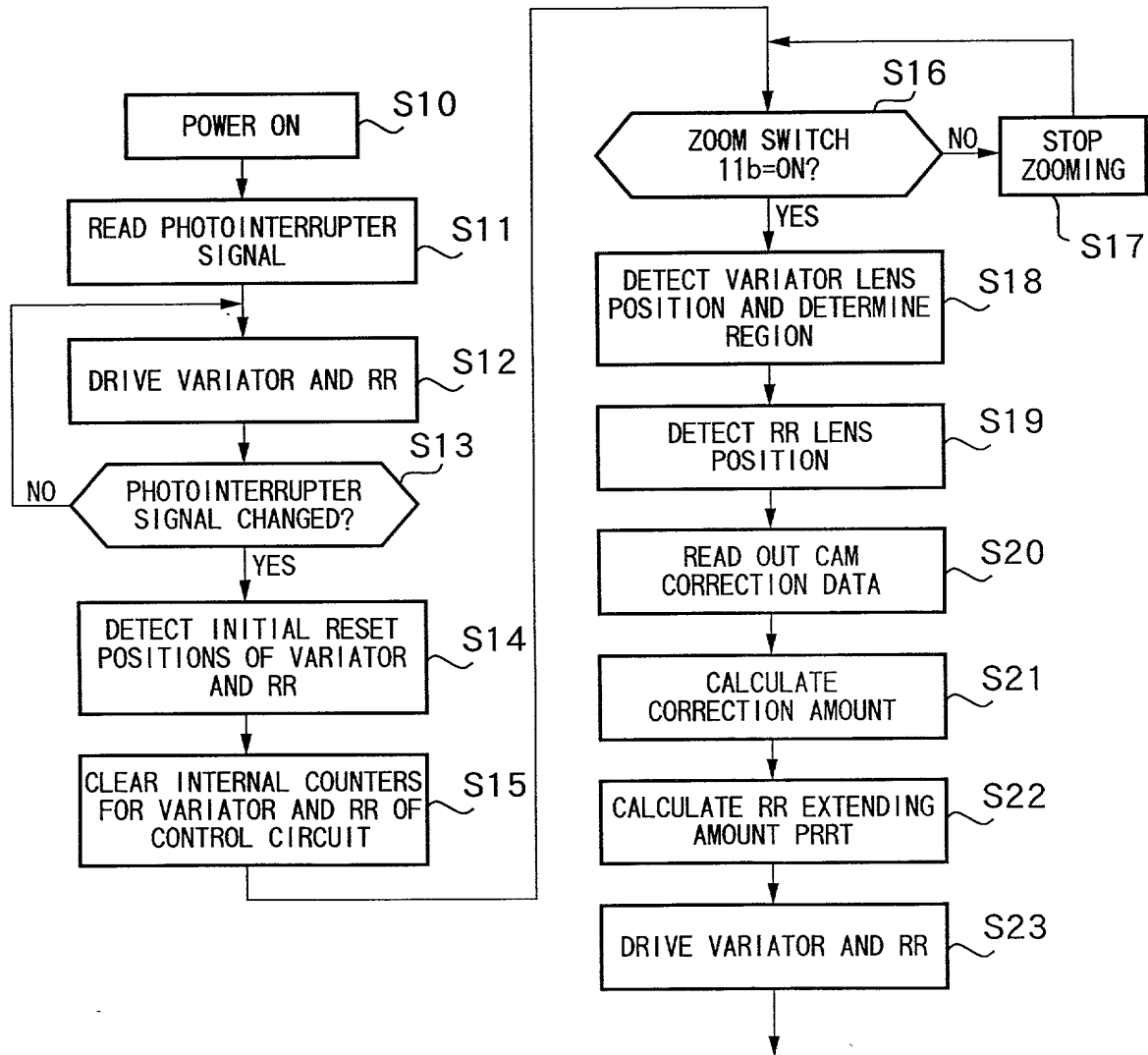


FIG. 7

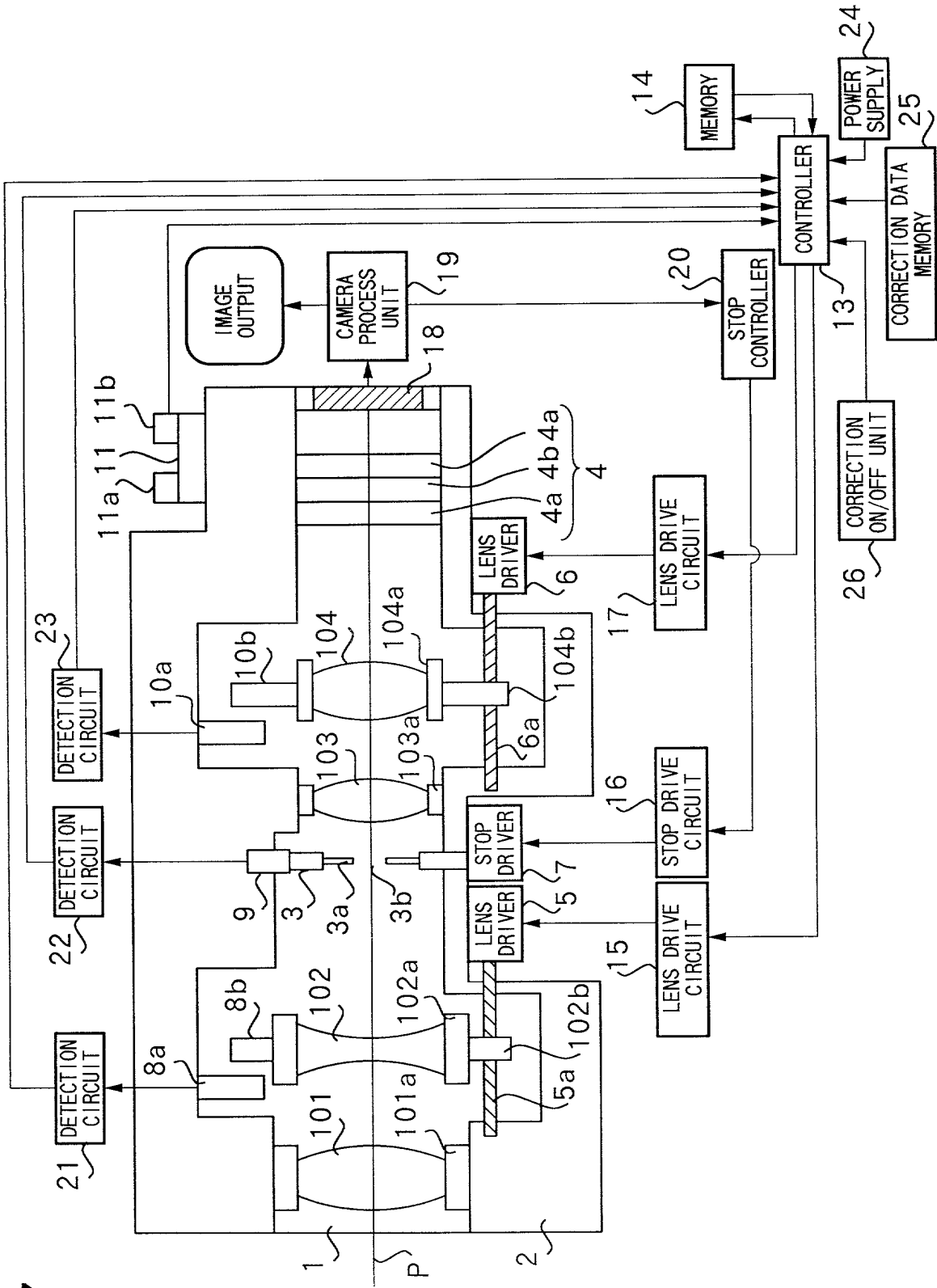


FIG.8

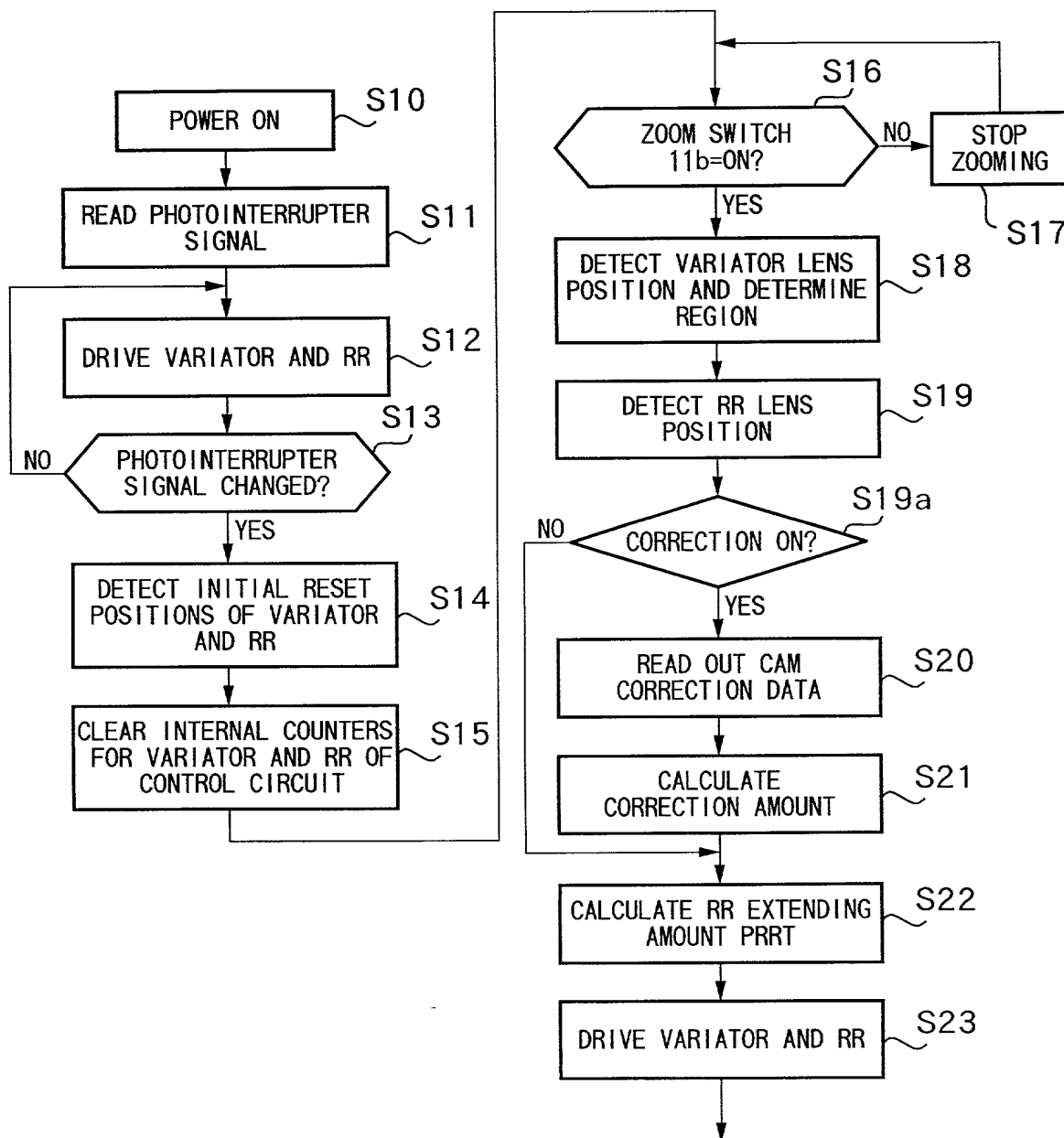


FIG.9

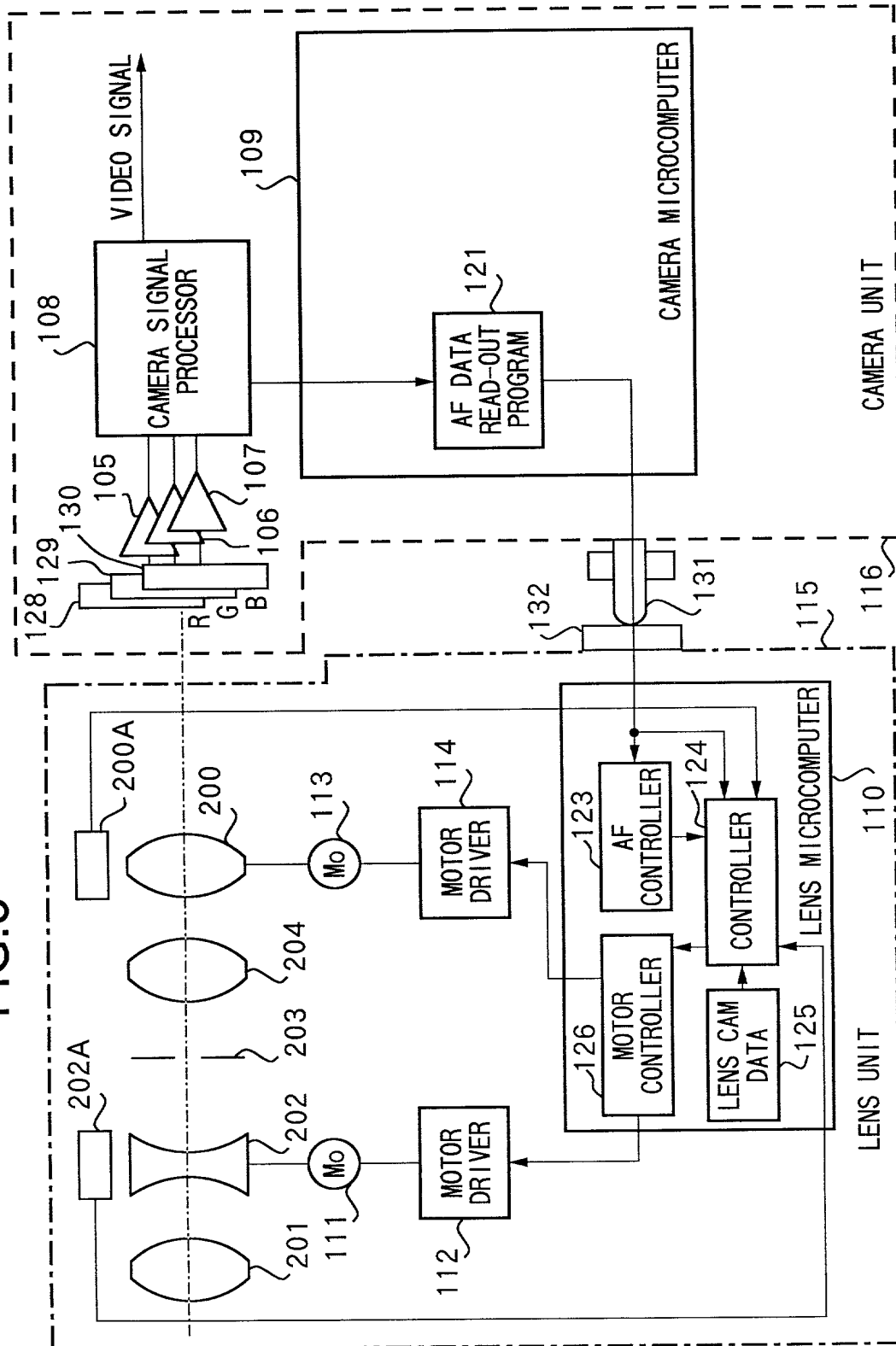


FIG.10

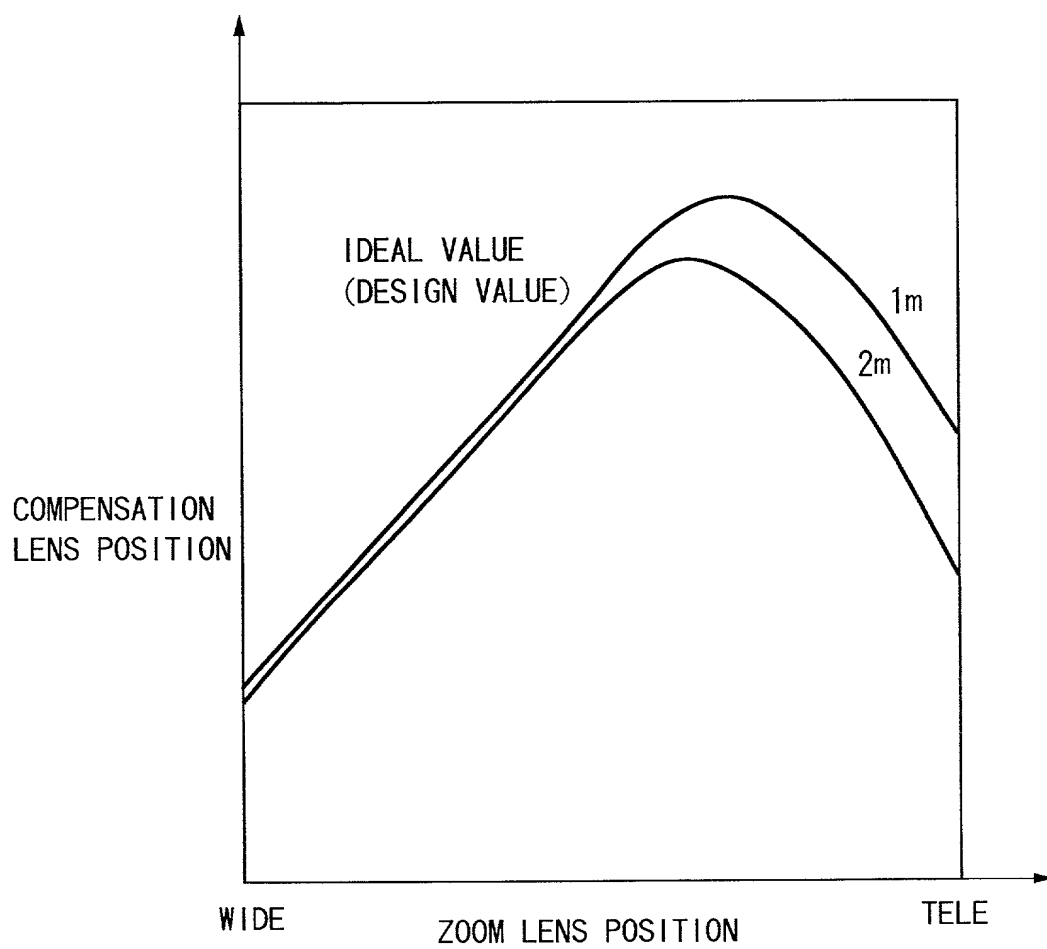


FIG.11

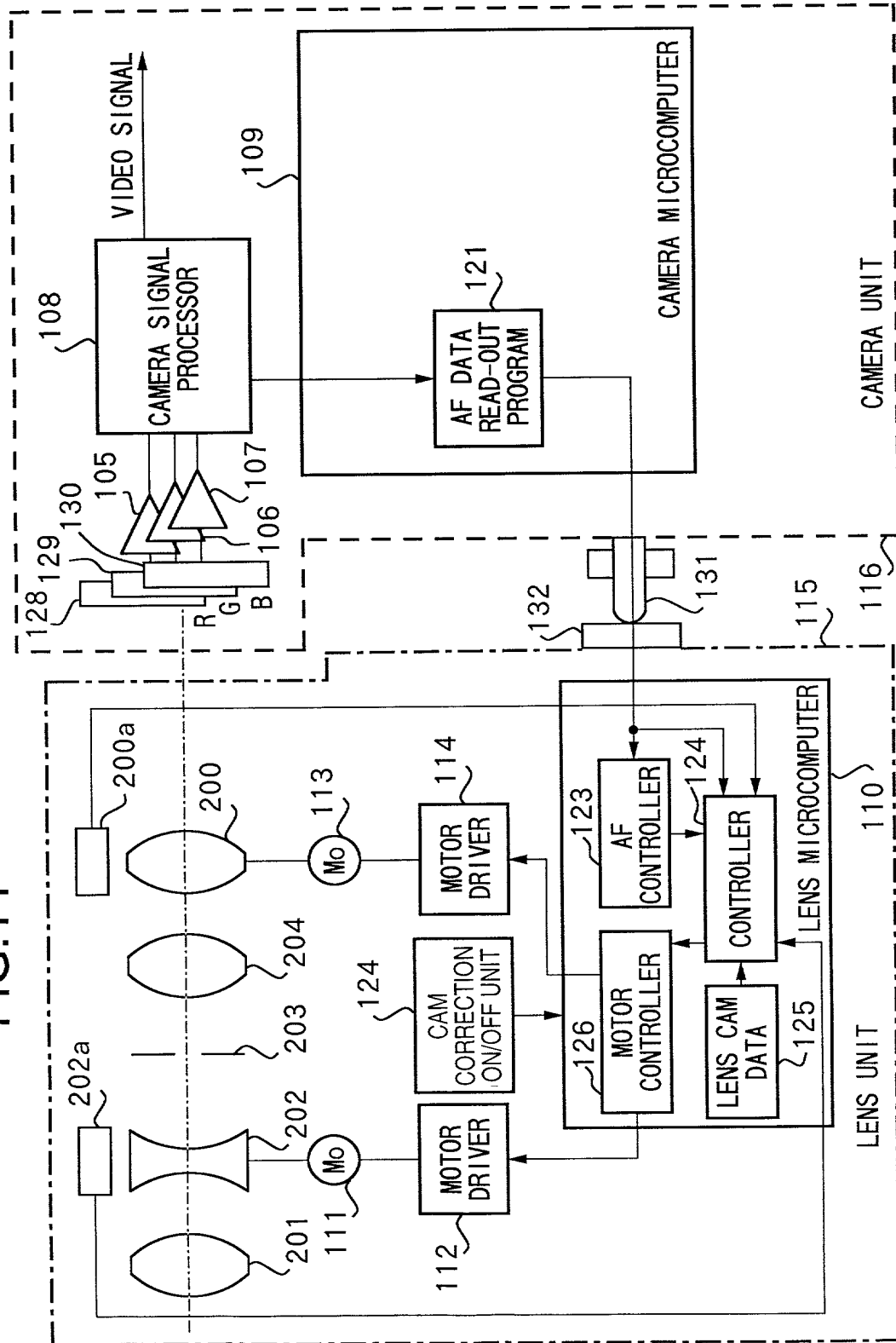


FIG.12

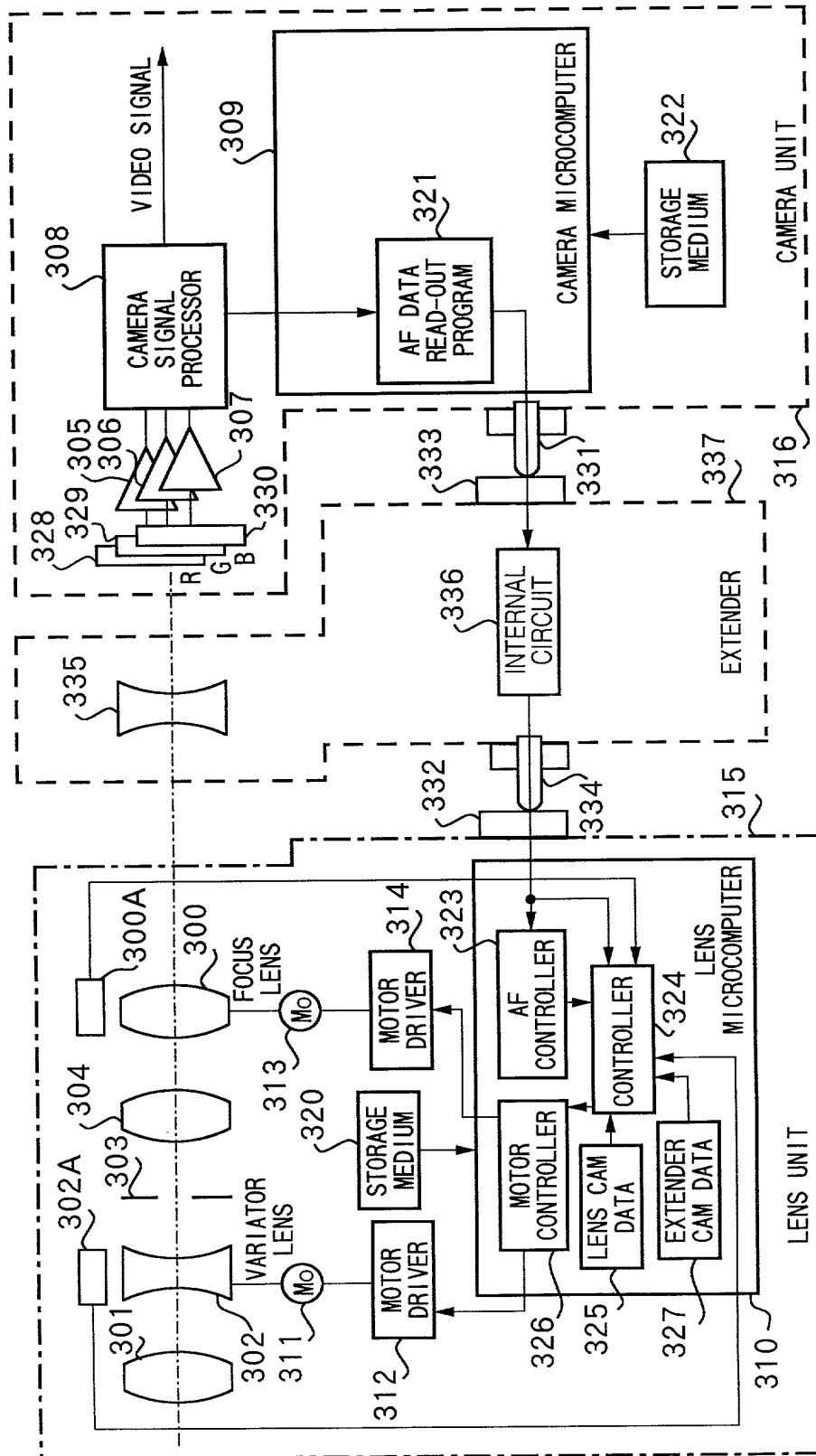


FIG.13

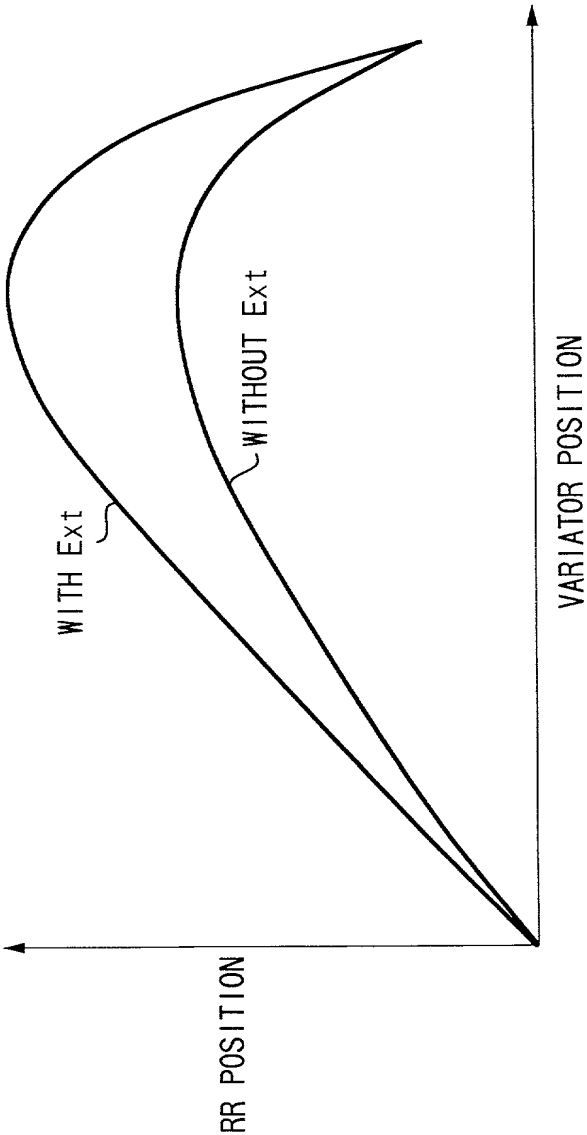


FIG.14

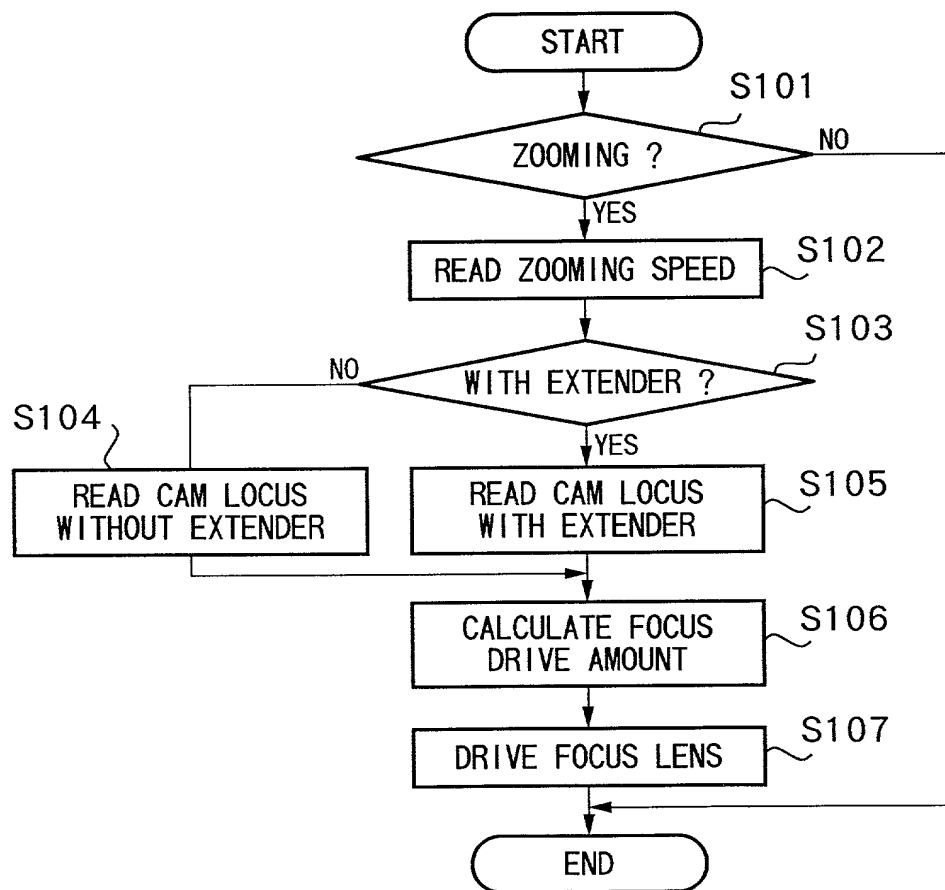


FIG.15

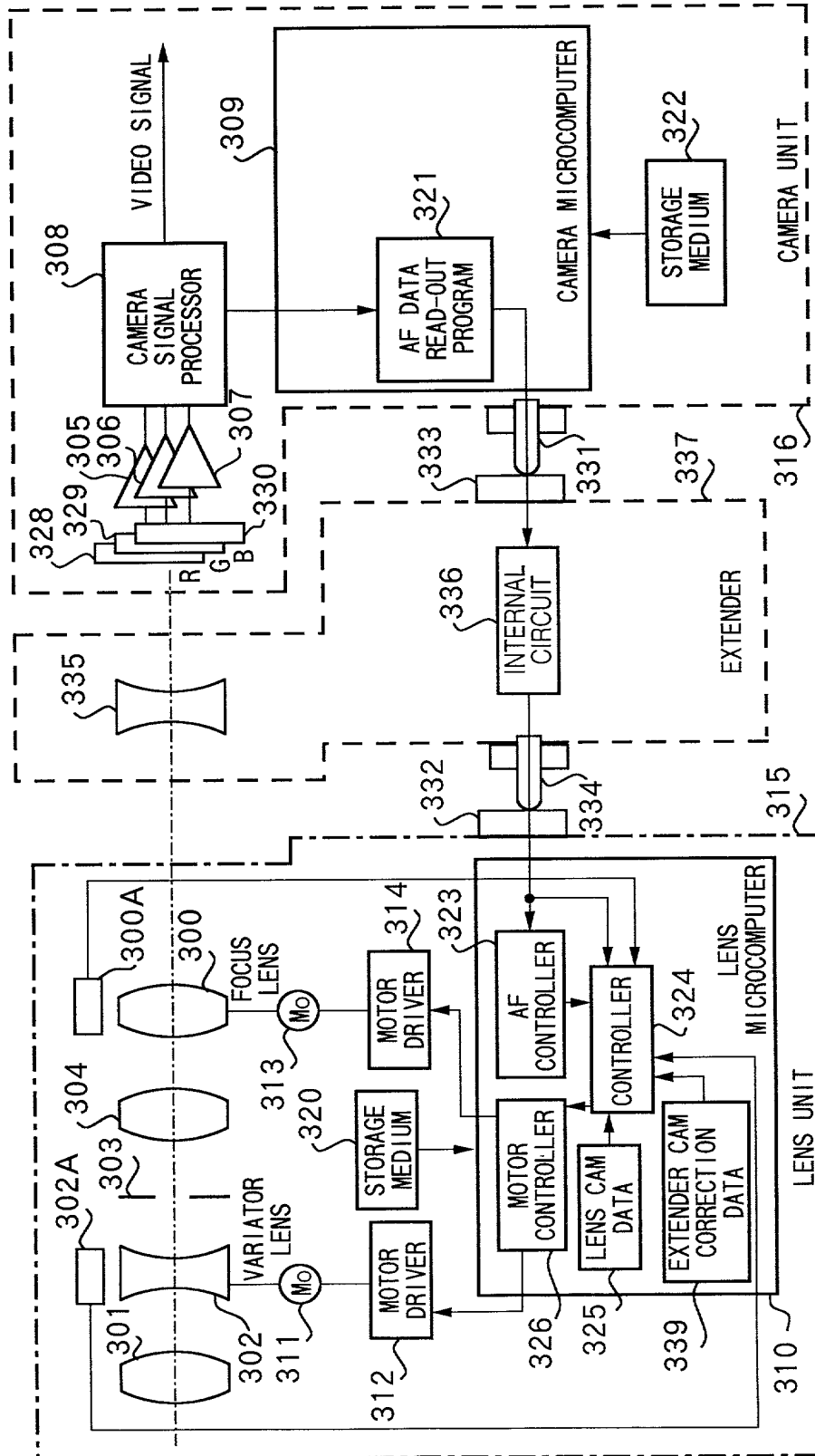


FIG.16

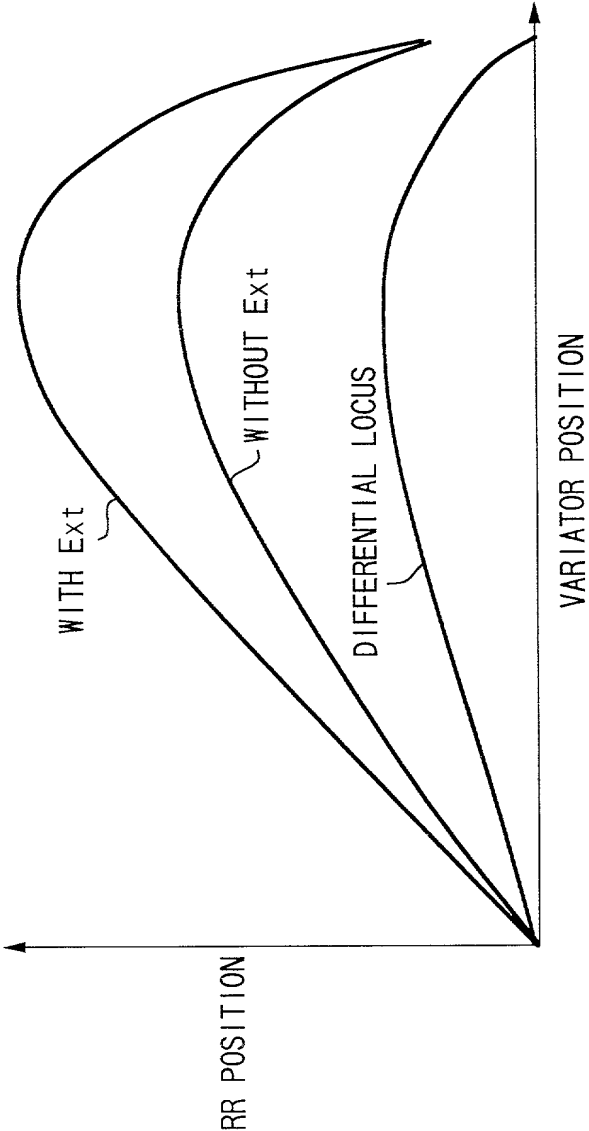


FIG.17

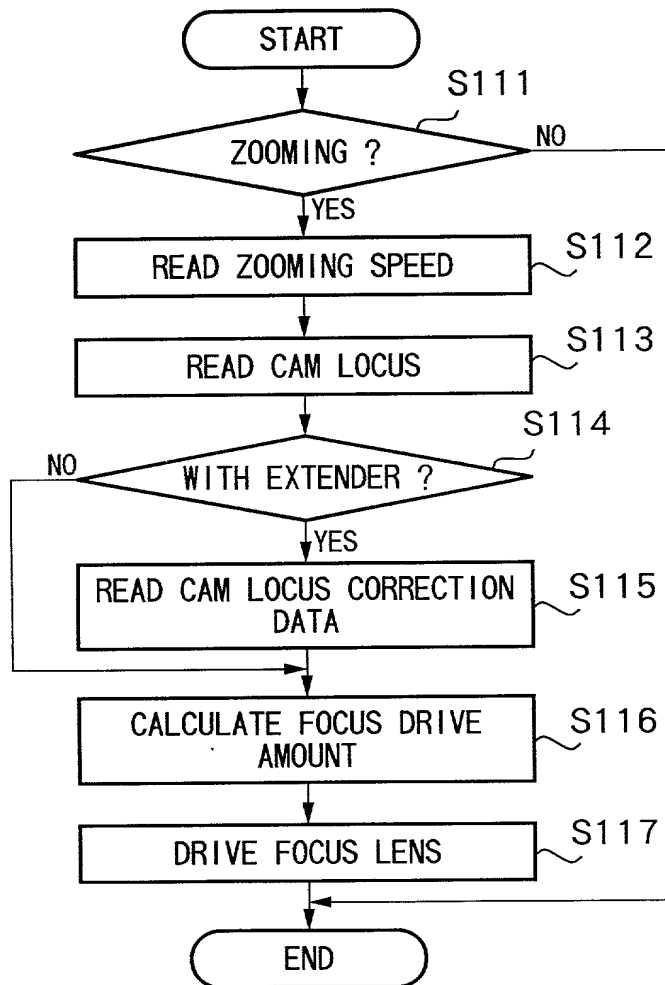


FIG.18

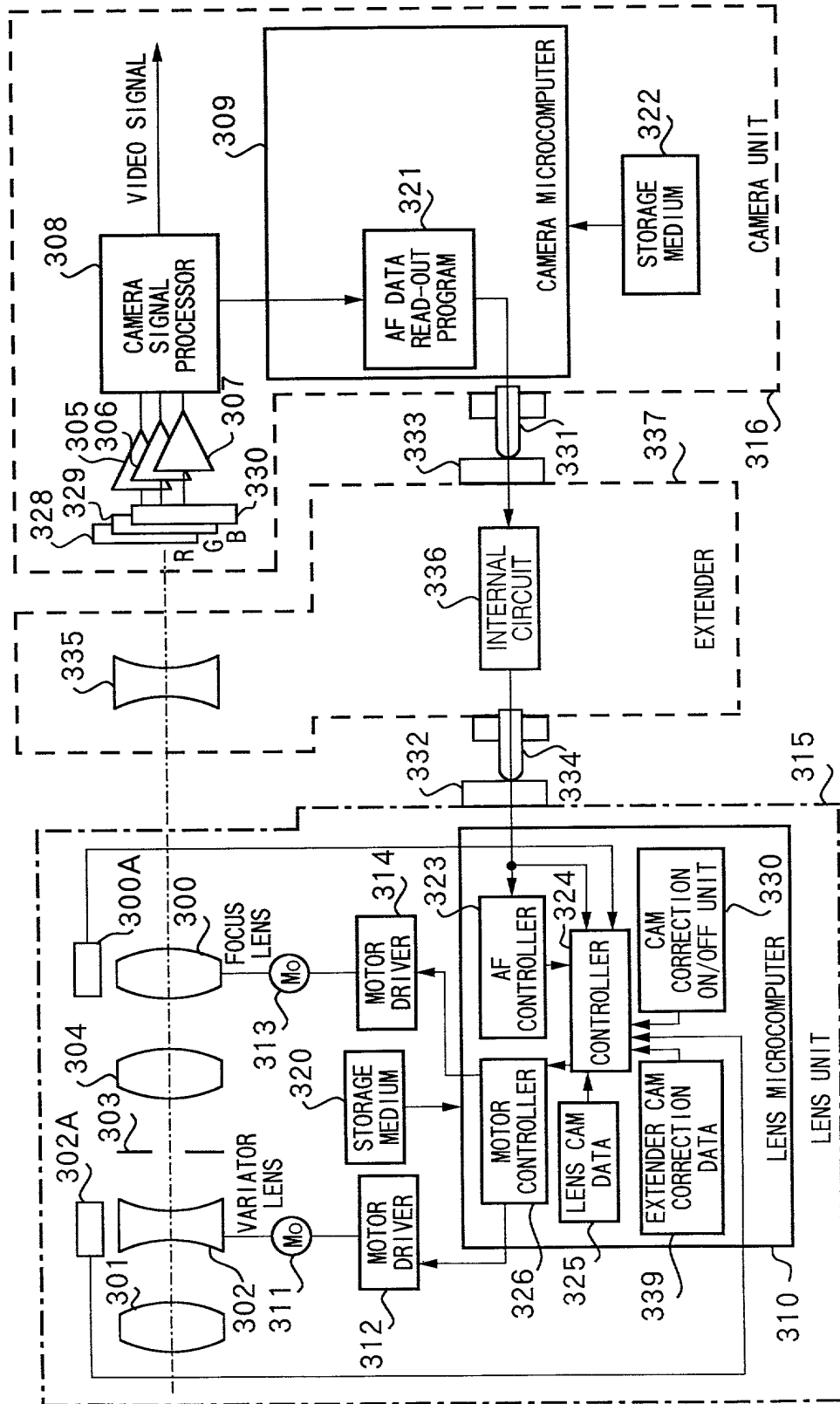


FIG.19

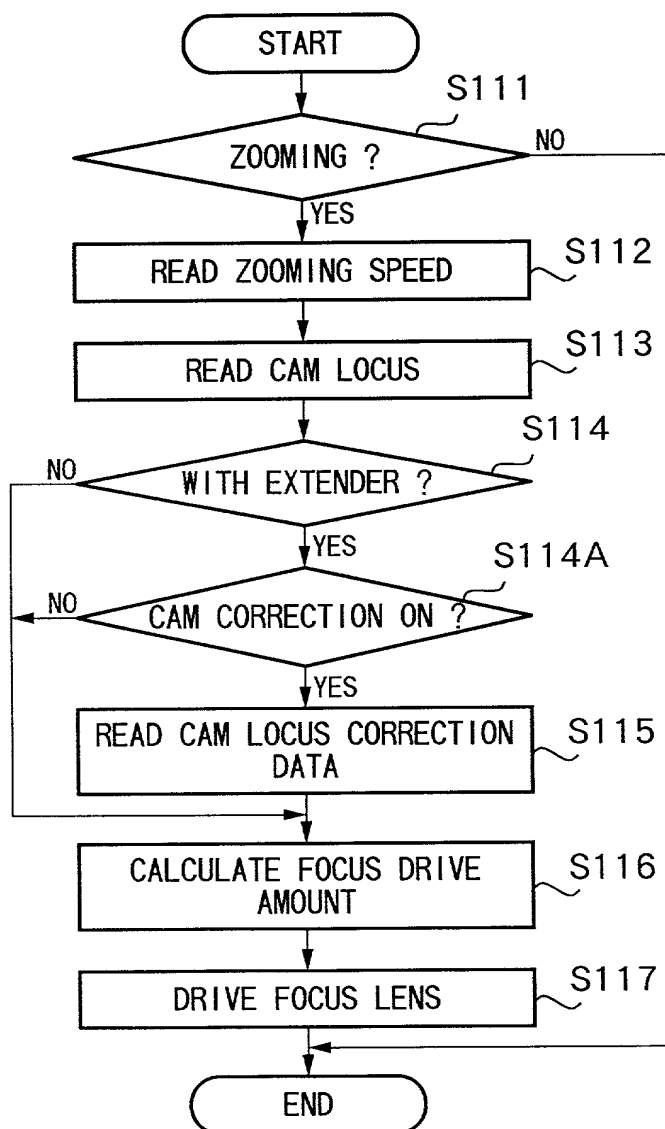


FIG. 20

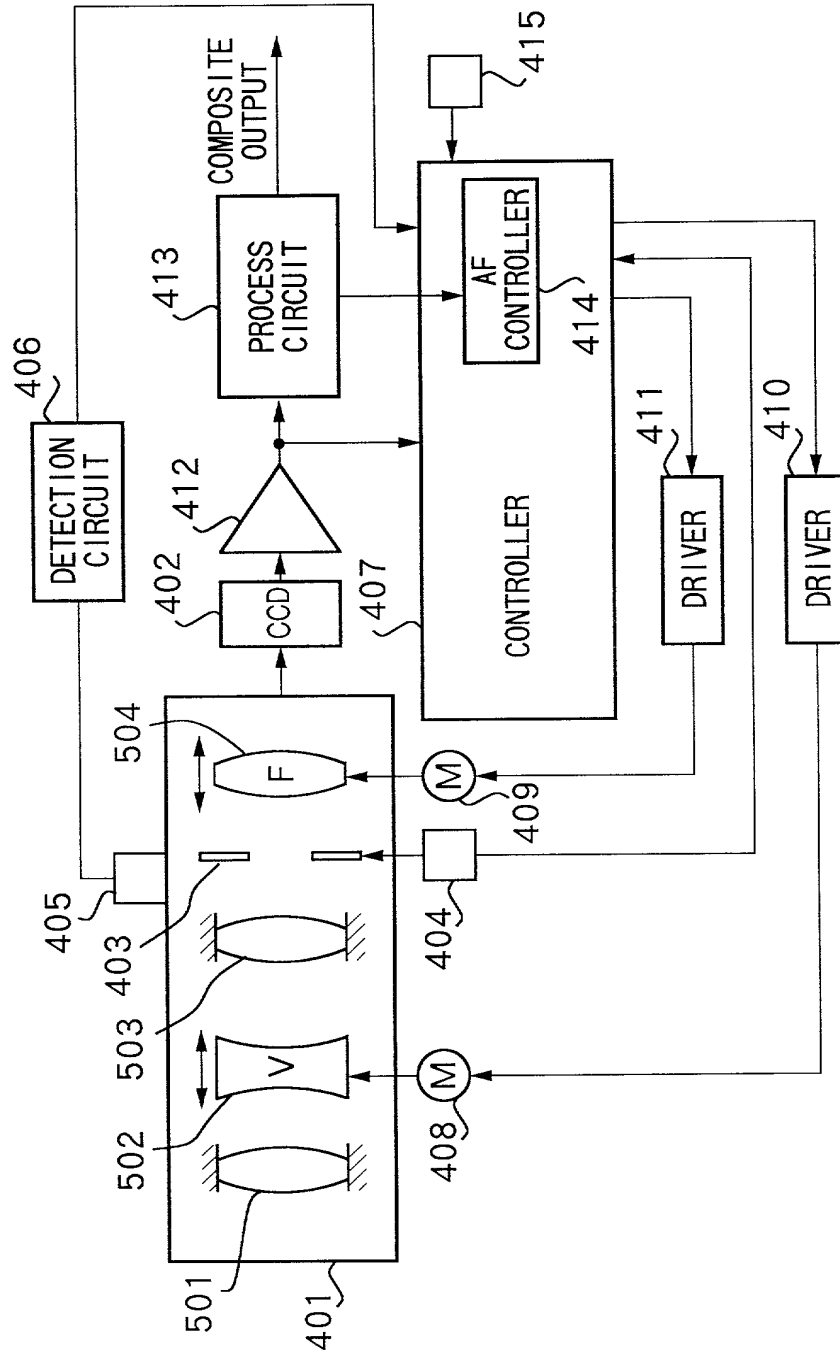
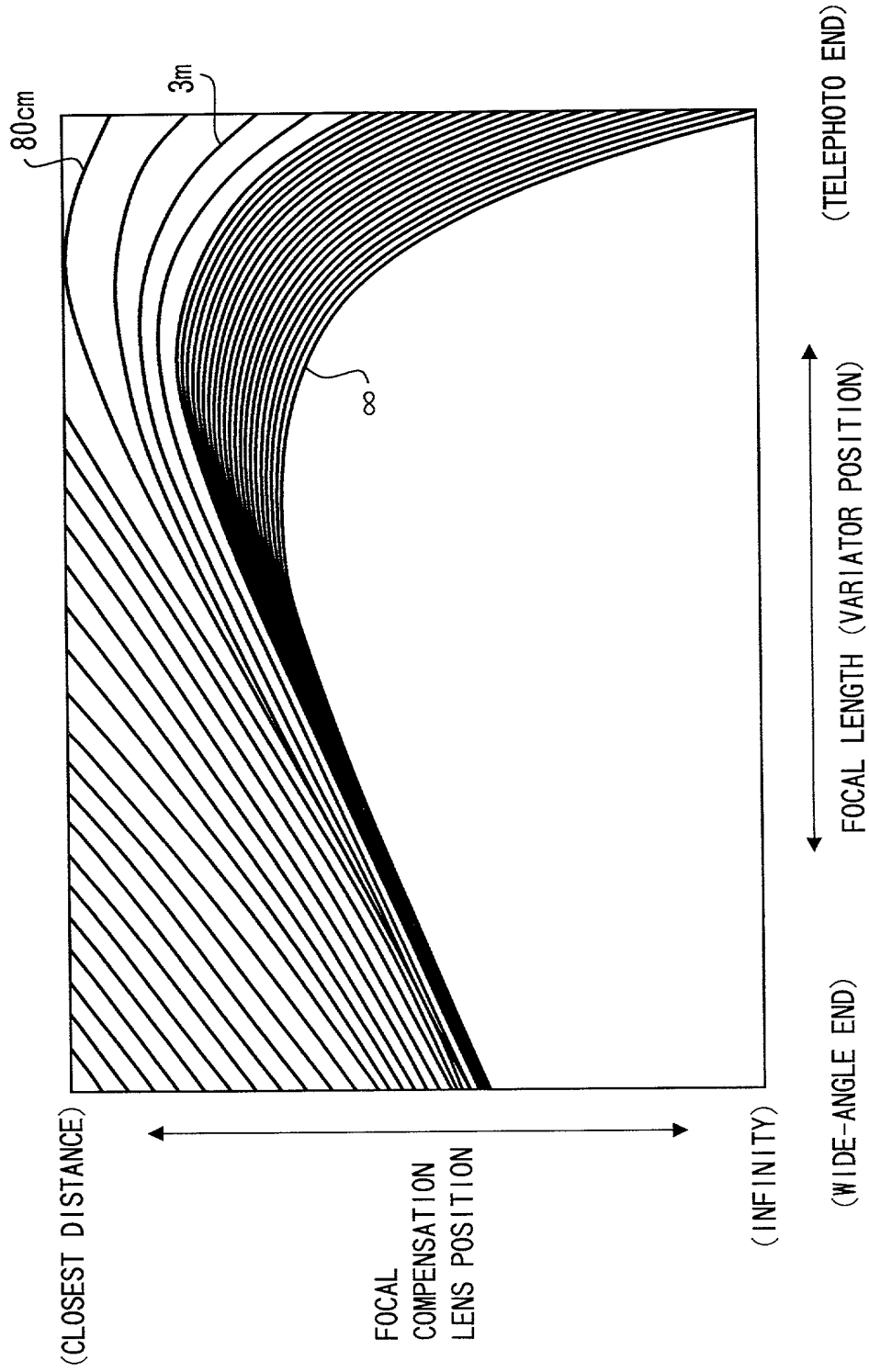


FIG.21



Parameter	Unit	Value	Standard Error	95% CI	P-value
Intercept		0.000	0.000	0.000	0.000
Age	Year	0.000	0.000	0.000	0.000
Gender		0.000	0.000	0.000	0.000
Education	Year	0.000	0.000	0.000	0.000
Income	Year	0.000	0.000	0.000	0.000
Health		0.000	0.000	0.000	0.000
Marital		0.000	0.000	0.000	0.000
Occupation		0.000	0.000	0.000	0.000
Religion		0.000	0.000	0.000	0.000
Region		0.000	0.000	0.000	0.000
Constant		0.000	0.000	0.000	0.000



FIG.23

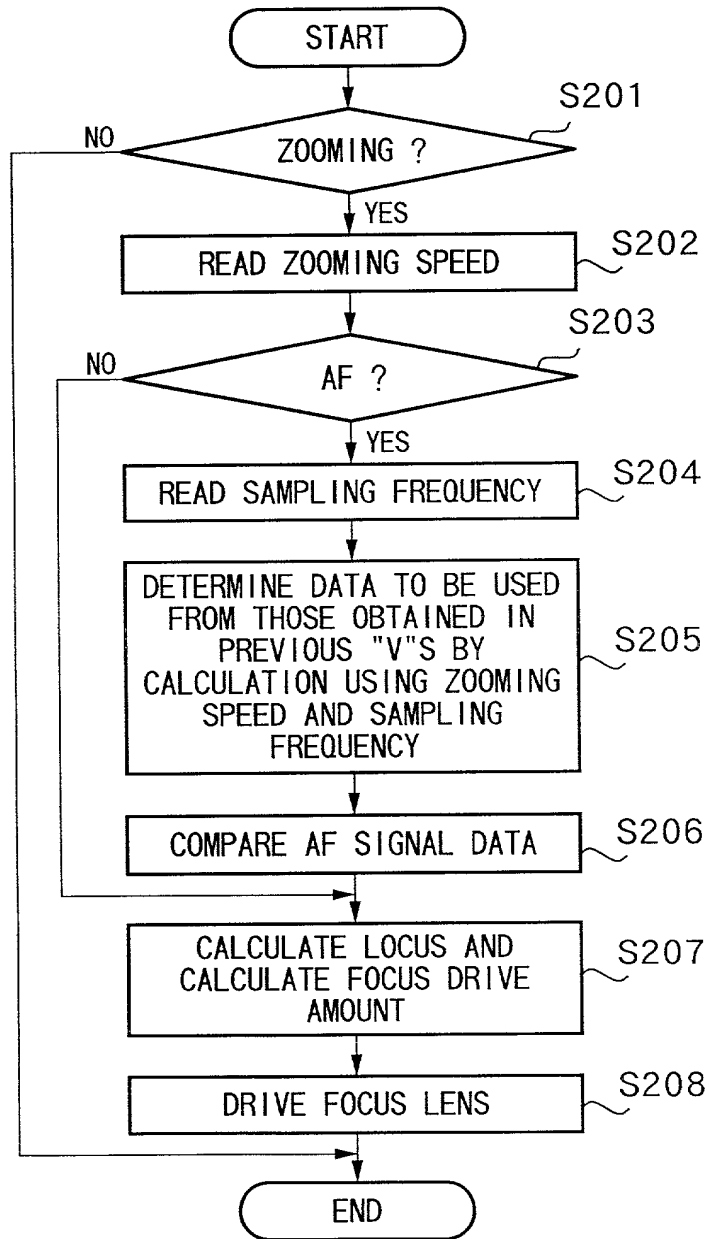


FIG.24

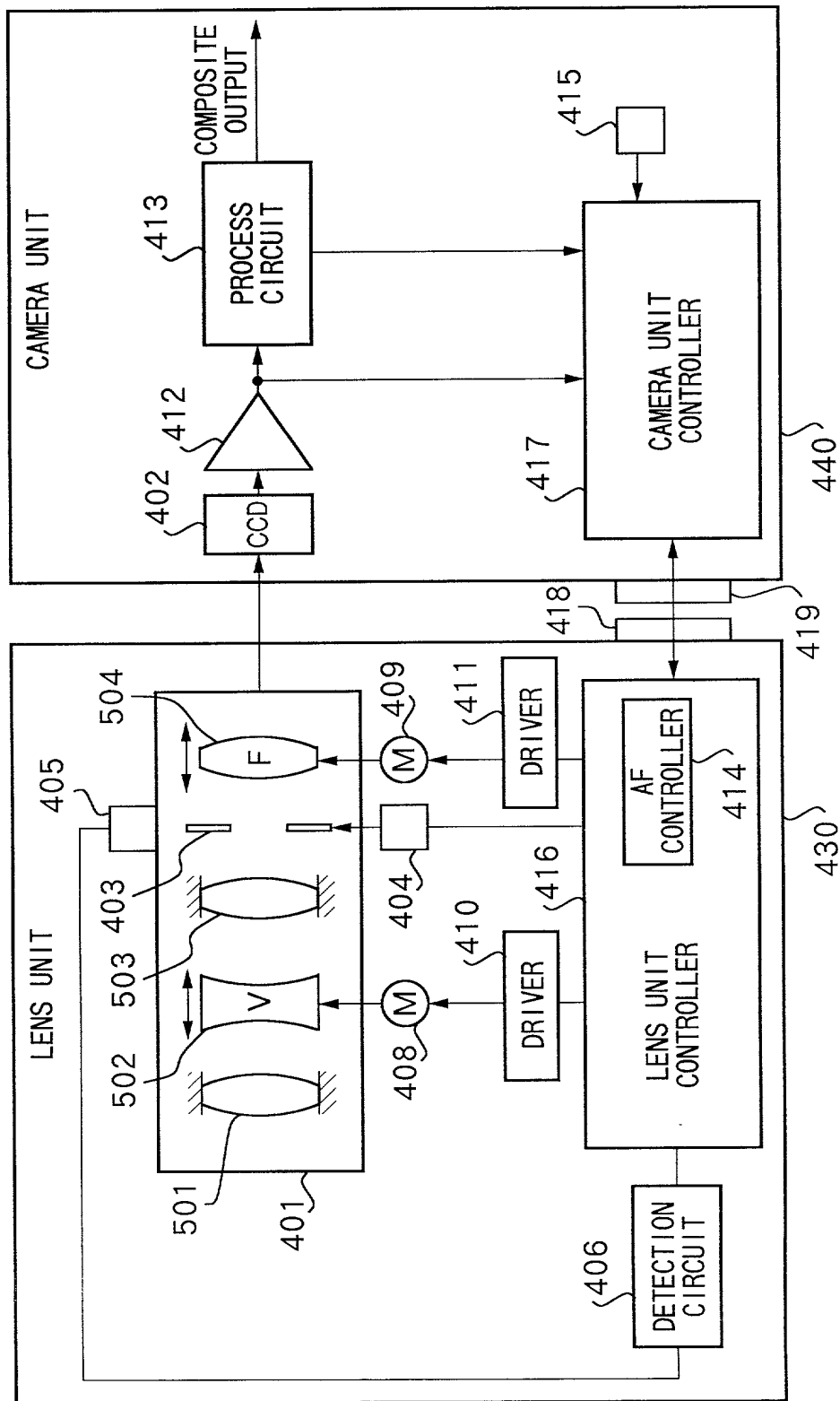


FIG.25

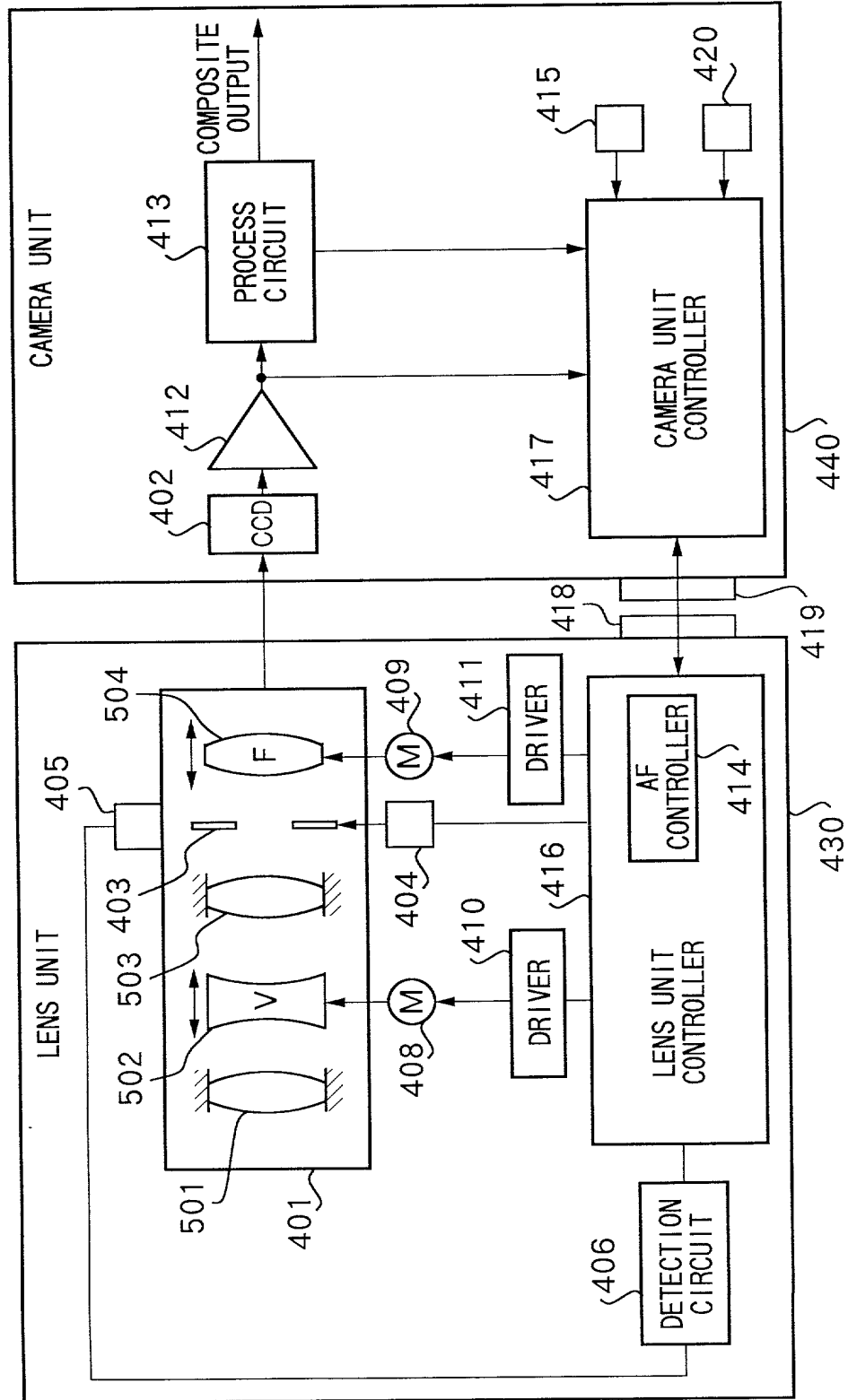


FIG.26

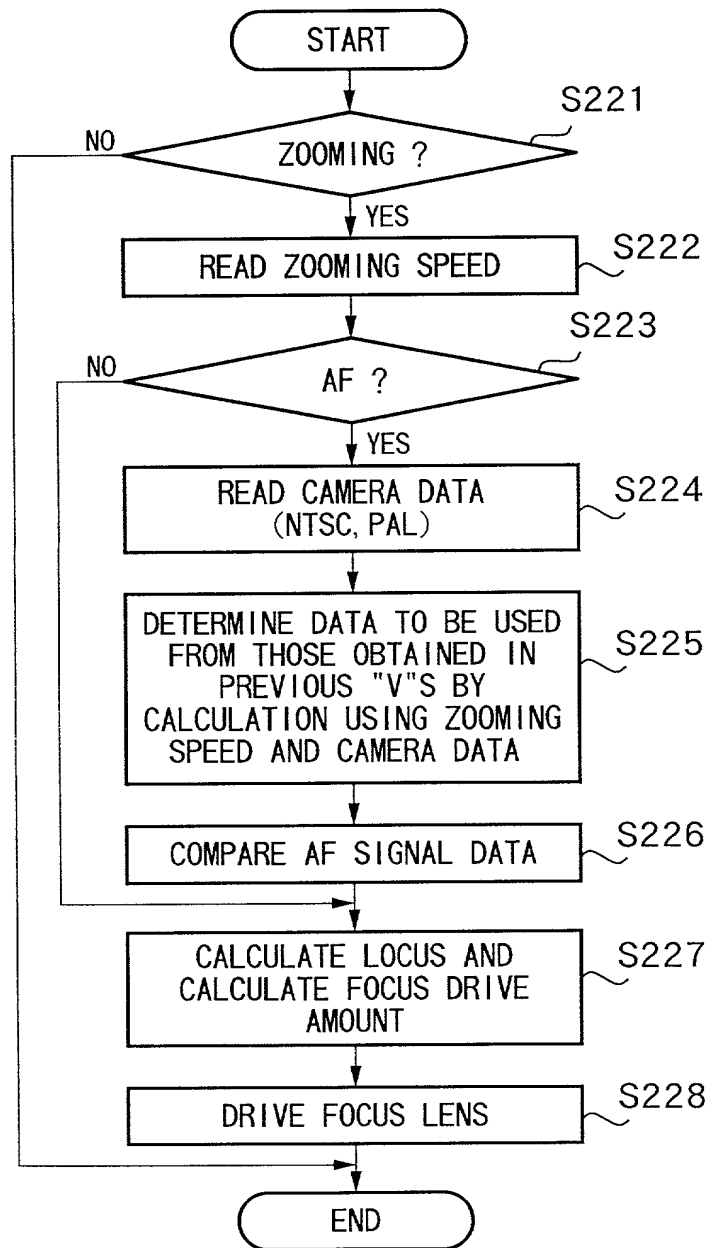


FIG. 27

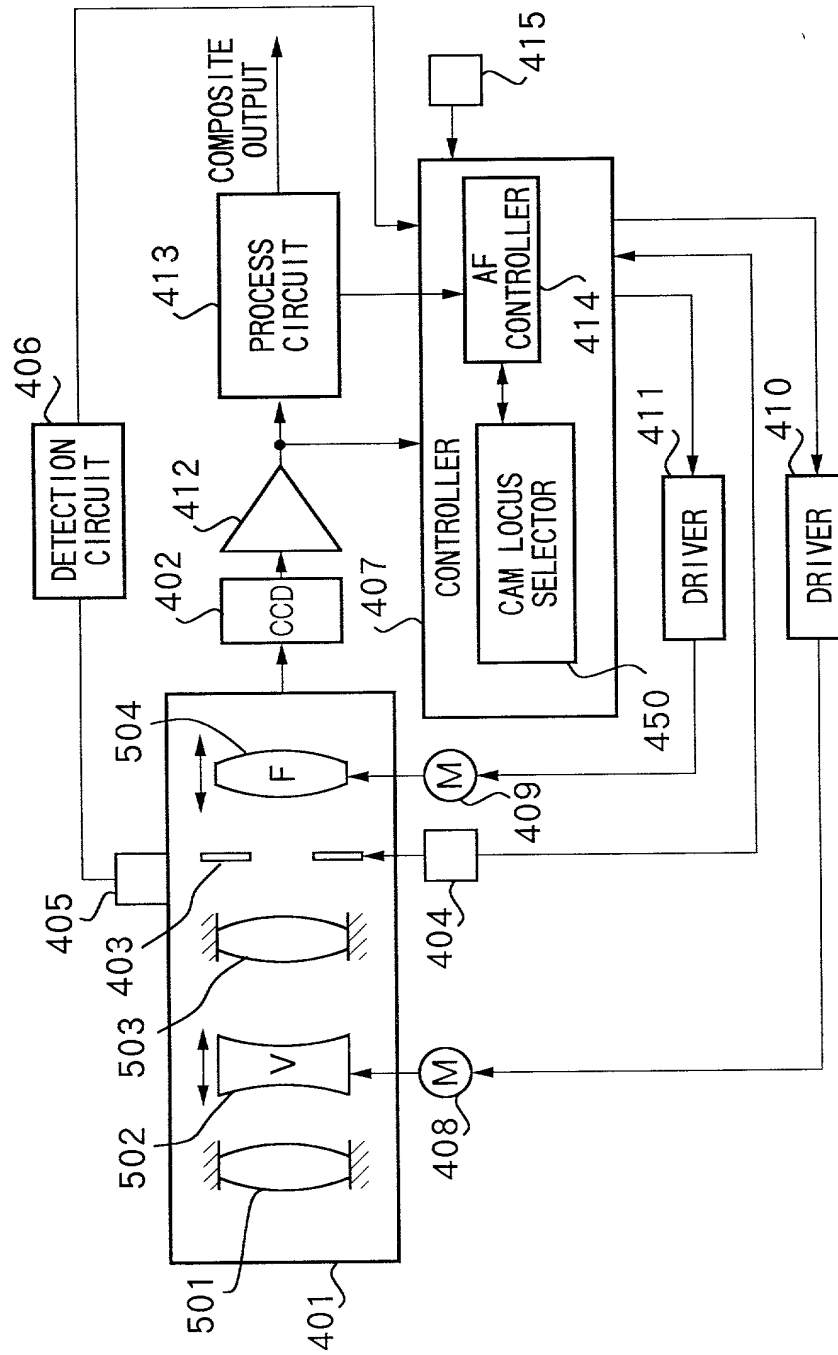


FIG.28

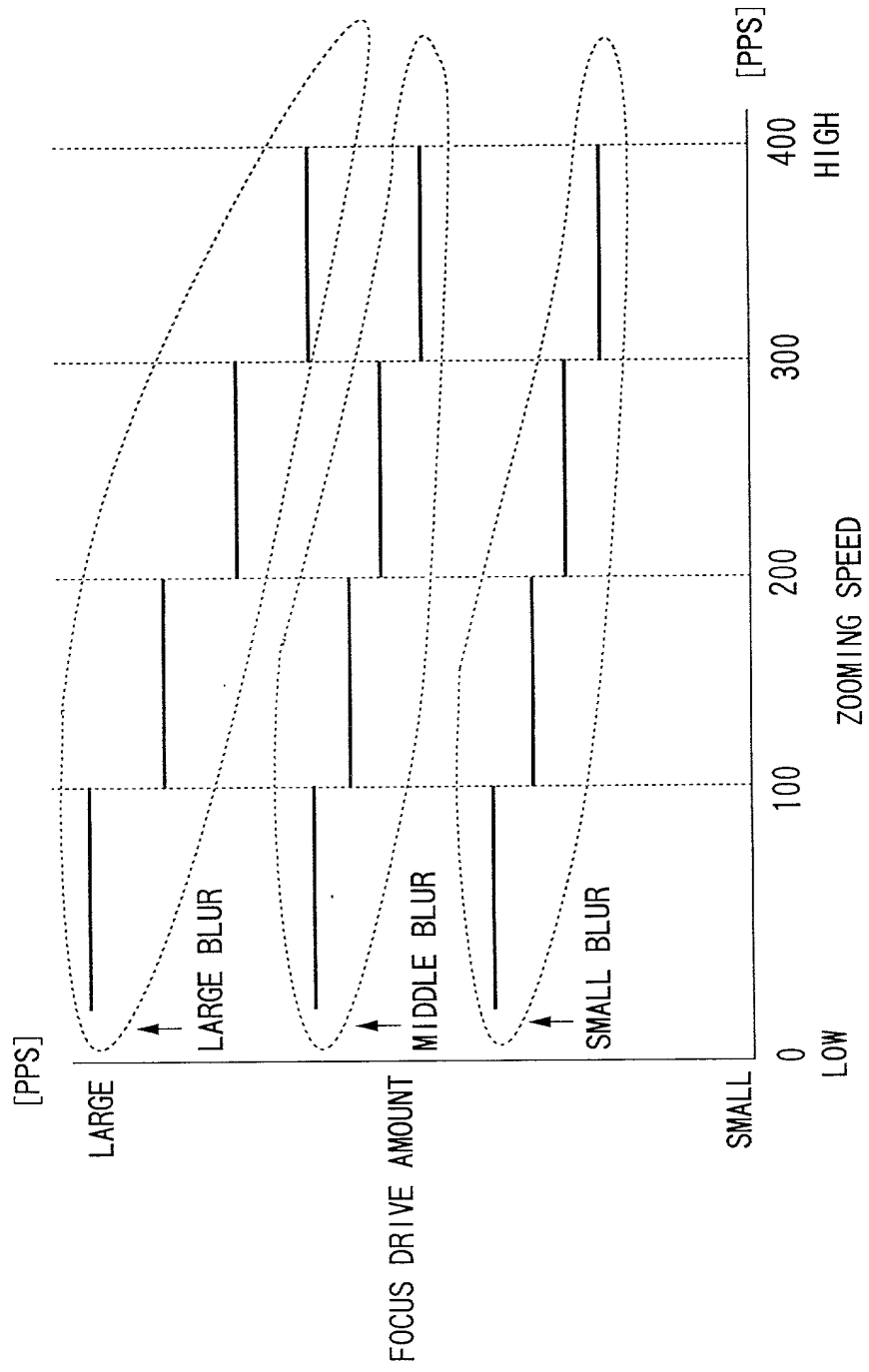


FIG.29

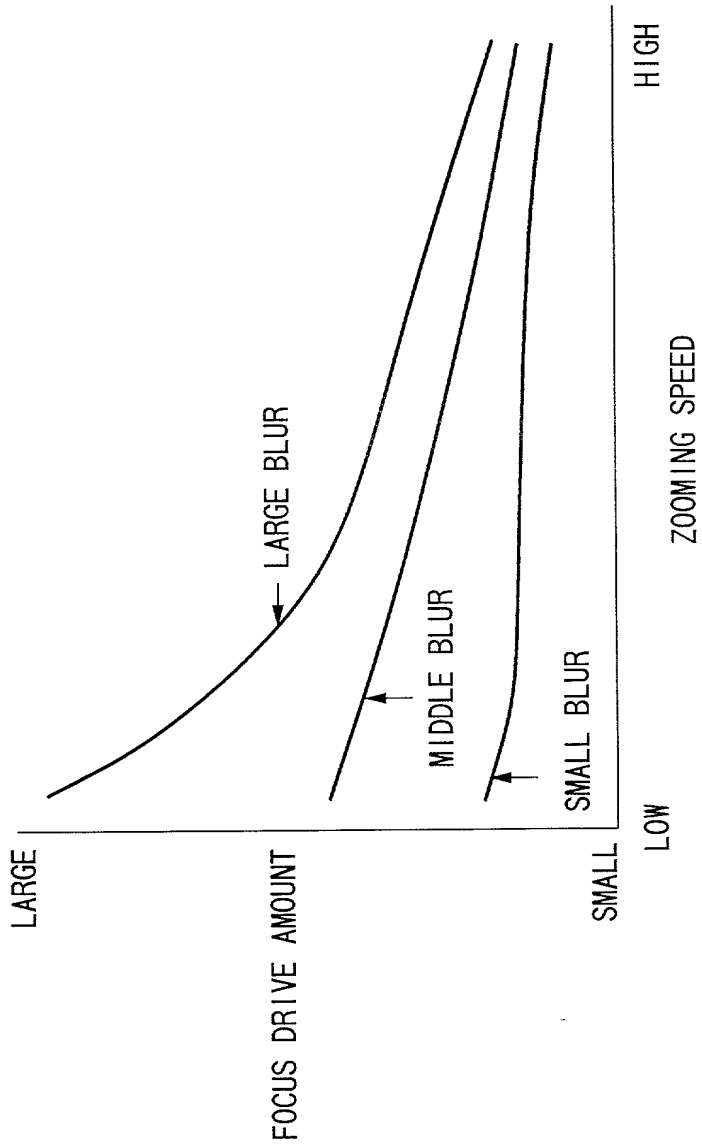


FIG.30

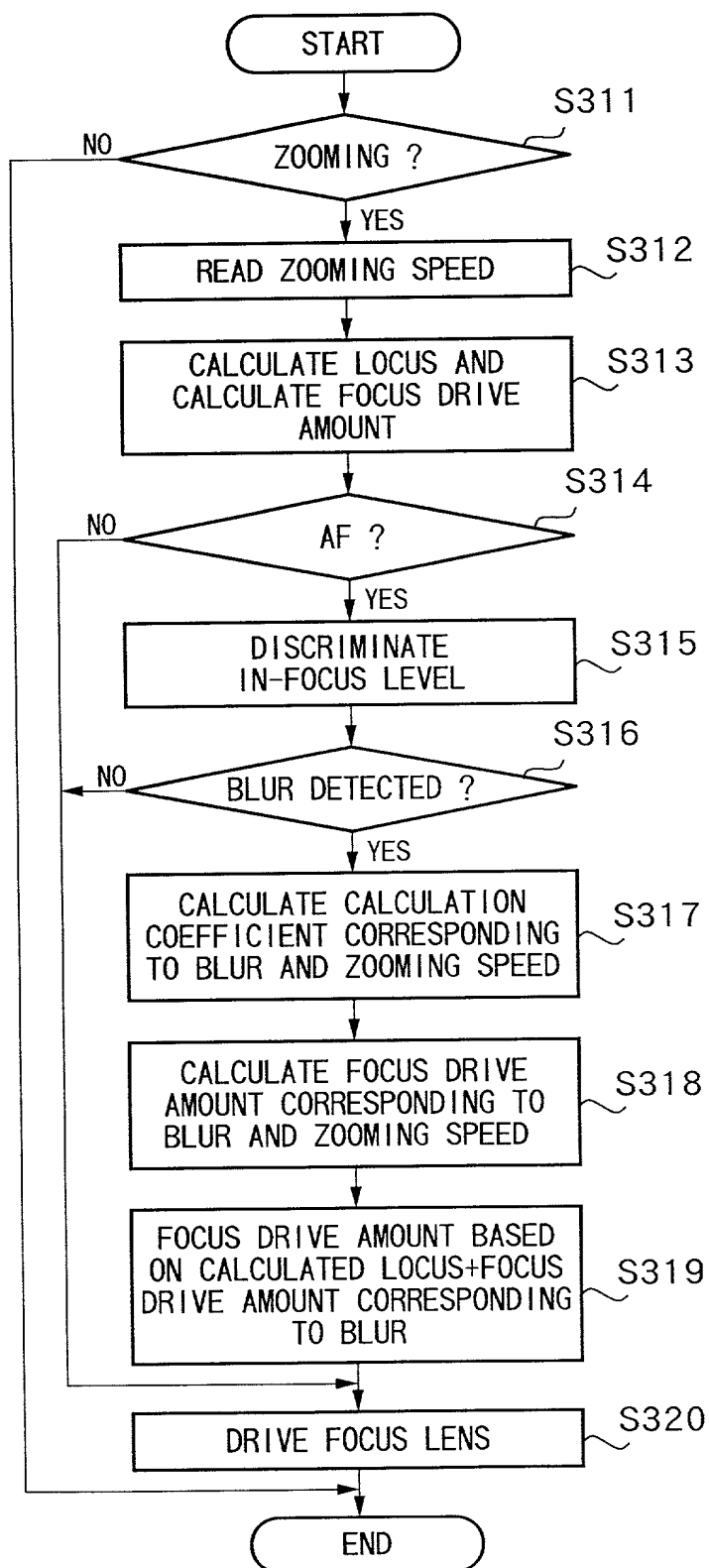
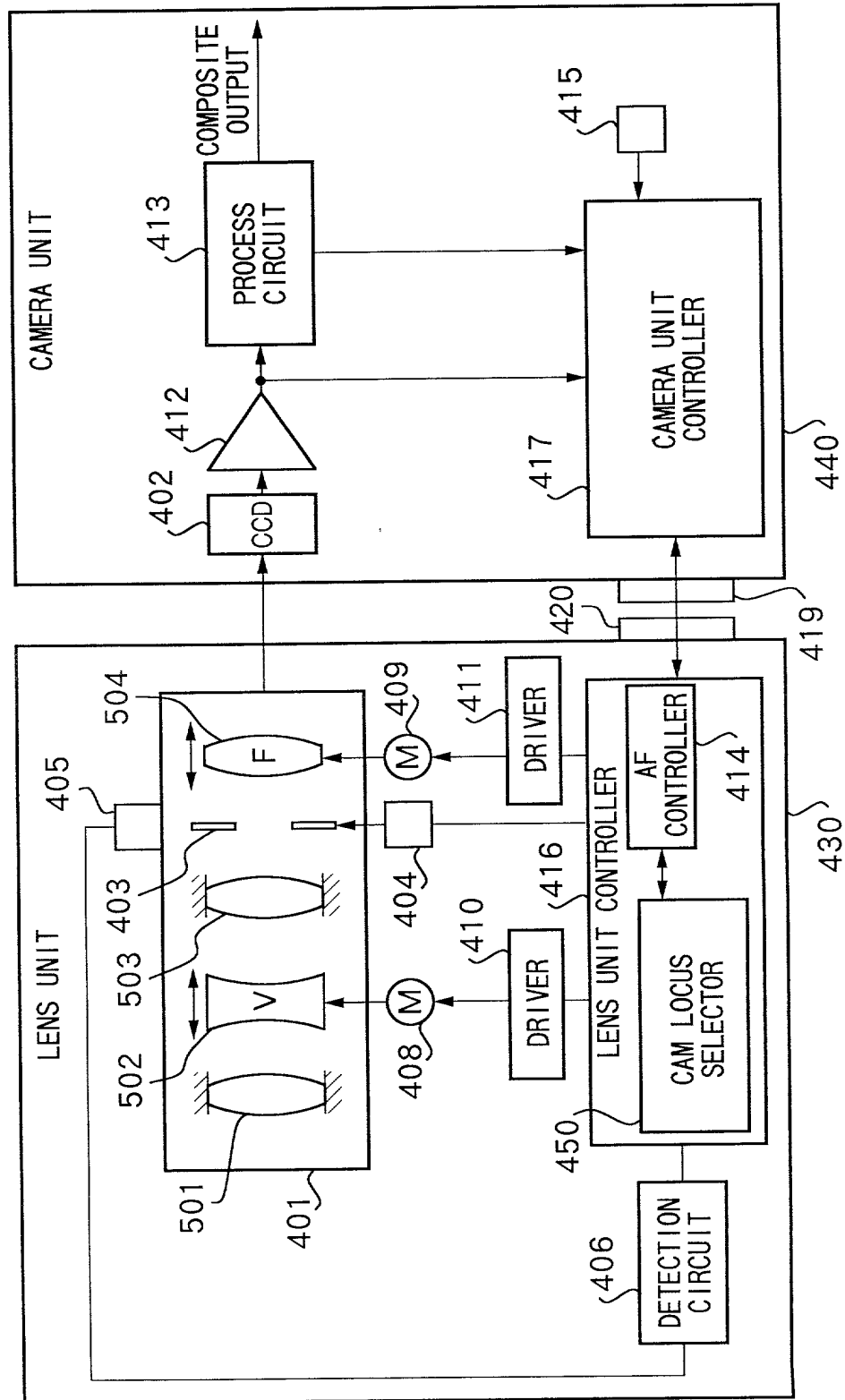


FIG.31



Docket No. _____

COMBINED DECLARATION AND POWER OF ATTORNEY FOR
ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL,
DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

OPTICAL EQUIPMENT AND ITS CONTROL METHOD, AND COMPUTER-READABLE STORAGE MEDIUM, the specification of which

a. ☒ is attached hereto

b. ☐ was filed on _____ as application Serial No. _____ and
was amended on _____ (if applicable).

PCT FILED APPLICATION ENTERING NATIONAL STAGE

C. ☐ was described and claimed in International Application No. _____ filed on
_____ and as amended on _____ (if any).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby specify the following as the correspondence address to which all communications about this application are to be directed:

SEND CORRESPONDENCE TO:

MORGAN & FINNEGAN, L.L.P.
345 Park Avenue
New York, N.Y. 10154

DIRECT TELEPHONE CALLS TO: Michael M. Murray

(212) 758-4800

☒ I hereby claim foreign priority benefits under Title 35, United States Code § 119 (a)-(d) or under § 365(b) of any foreign application(s) for patent or inventor's certificate or under § 365(a) of any PCT international application(s) designating at least one country other than the U.S. listed below and also have identified below such foreign application(s) for patent or inventor's certificate or such PCT international application(s) filed by me on the same subject matter having a filing date within twelve (12) months before that of the application on which priority is claimed:

☒ The attached 35 U.S.C. § 119 claim for priority for the U.S. application(s) listed below forms a part of this declaration.

<u>Country/PCT</u>	<u>Application Number</u>	<u>Date of filing (day,month,yr)</u>	<u>Date of issue (day,month,yr)</u>	<u>Priority Claimed</u>
JAPAN	9-350965	19/12/1997		[X]YES []NO
JAPAN	9-350966	19/12/1997		[X]YES []NO
JAPAN	9-364757	22/12/1997		[X]YES []NO
JAPAN	9-364759	22/12/1997		[X]YES []NO

[] I hereby claim the benefit under 35 U.S.C. § 119(e) of any U.S. provisional application(s) listed below.

Provisional Application No.

Date of filing (day, month, yr)

ADDITIONAL STATEMENTS FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART
OR PCT INTERNATIONAL APPLICATION(S DESIGNATING THE U.S.)

I hereby claim the benefit under Title 35, United States Code § 120 of any United States application(s) or under § 365(c) of any PCT international application(s) designating the U.S. listed below.

<u>US/PCT Application Serial No.</u>	<u>Filing Date,</u>	<u>Status (patented, pending, abandoned)/ U.S. application no. assigned (For PCT)</u>
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<u>US/PCT Application Serial No.</u>	<u>Filing Date,</u>	<u>Status (patented, pending, abandoned)/ U.S. application no. assigned (For PCT)</u>
--------------------------------------	---------------------	---

[] In this continuation-in-part application, insofar as the subject matter of any of the claims of this application is not disclosed in the above listed prior United States or PCT international application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or Imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

I hereby appoint the following attorneys and/or agents with full power of substitution and revocation, to prosecute this application, to receive the patent, and to transact all business in the Patent and Trademark Office connected therewith: John A. Diaz (Reg. No. 19,550), John C. Vassil (Reg. No. 19,098), Alfred P. Ewert (Reg. No. 19,887), David H. Pfeffer, P.C. (Reg. No. 19,825), Harry C. Marcus (Reg. No. 22,390), Robert E. Paulson (Reg. No. 21,046), Stephen R. Smith (Reg. No. 22,615), Kurt E. Richter (Reg. No. 24,052), J. Robert Dailey (Reg. No. 27,434), Eugene Moroz (Reg. No. 25,237), John F. Sweeney (Reg. No. 27,471), Arnold I. Rady (Reg. No. 26,601), Christopher A. Hughes

Docket No. _____

(Reg. No. 26,914), William S. Feiler (Reg. No. 26,728), Joseph A. Calvaruso (Reg. No. 28,287), James W. Gould (Reg. No. 28,859), Richard C. Komson (Reg. No. 27,913), Israel Blum (Reg. No. 26,710), Bartholomew Verdirame (Reg. No. 28,483), Maria C. H. Lin (Reg. No. 29,323), Joseph A. DeGirolamo (Reg. No. 28,595), Michael A. Nicodema (Ref. No. 33,199), Michael P. Dougherty (Ref. No. 32,730), Seth J. Altas (Reg. No. 32,454), Andrew M. Riddles (Reg. No. 31,657), Bruce D. DeRenzi (Reg. No. 33,676), Michael M. Murray (Reg. No. 32,537) and Mark J. Abate (Reg. No. 32,527) of Morgan & Finnegan, L.L.P. whose address is: 345 Park Avenue, New York, New York 10154; and Edward A. Pennington (Reg. No. 32,588) of Morgan & Finnegan, L.L.P., whose address is: 1299 Pennsylvania Avenue, N.W., Suite 960, Washington, D.C. 20004.

☐ I hereby authorize the U.S. attorneys and/or agents named hereinabove to accept and follow instructions from _____ as to any action to be taken in the U.S. Patent and Trademark Office regarding this application without direct communication between the U.S. attorneys and/or agents and me. In the event of a change in the person(s) from whom instructions may be taken I will so notify the U.S. attorneys and /or agents named hereinabove.

Full name of sole or first inventor Seiya OHTA

Inventor's signature* Seiya Ohta

date December 9, 1998

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Kanagawa-ken, Japan

Citizenship Japan

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30-2, Shimomaruko 3-chome, Ohta-ku, Tokyo, Japan

Full name of second joint inventor, if any _____

Inventor's signature* _____

date

Residence _____

Citizenship _____

Post Office Address _____

☐ ATTACHED IS ADDED PAGE TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR SIGNATURE BY THIRD AND SUBSEQUENT INVENTORS FORM.

* Before signing this declaration, each person signing must:

1. Review the declaration and verify the correctness of all information therein; and
2. Review the specification and the claims, including any amendments made to the claims.

After the declaration is signed, the specification and claims are not to be altered.

To the inventor(s):

The following are cited in or pertinent to the declaration attached to the accompanying application:

Title 37, Code of Federal Regulation, §1.56

Duty to disclose information material to patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

Title 35, U.S. Code § 101

Inventions patentable

Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Title 35 U.S. Code § 102

Conditions for patentability; novelty and loss of right to patent

A person shall be entitled to a patent unless --

- (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent,
- (b) the invention was patented or described in a printed publication in this or foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States, or

(c) he has abandoned the invention, or

(d) the invention was first patented or caused to be patented, or was the subject of an inventor's certificate, by the applicant or his legal representatives or assigns in a foreign country prior to the date of the application for patent in this country on an application for patent or inventor's certificate filed more than twelve months before the filing of the application in the United States, or

(e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent, or

(f) he did not himself invent the subject matter sought to be patented, or

(g) before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it. In determining priority of invention there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other ...

Title 35, U.S. Code § 103

Conditions for patentability; non-obvious subject matter

A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

Title 35, U.S. Code § 112 (in part)

Specification

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Title 35, U.S. Code, § 119

Benefit of earlier filing date in foreign country; right of priority

An application for patent for an invention filed in this country by any person who has, or whose legal representatives or assigns have, previously regularly filed an application for a patent for the same invention in a foreign country which affords similar privileges in the case of applications filed in the United States or to citizens of the United States, shall have the same effect as the same application would have if filed in this

country on the date on which the application for patent for the same invention was first filed in such foreign country, if the application in this country is filed within twelve months from the earliest date on which such foreign application was filed; but no patent shall be granted on any application for patent for an invention which had been patented or described in a printed publication in any country more than one year before the date of the actual filing of the application in this country, or which had been in public use or on sale in this country more than one year prior to such filing.

Title 35, U.S. Code, § 120

Benefit or earlier filing date in the United States

An application for patent for an invention disclosed in the manner provided by the first paragraph of section 112 of this title in an application previously filed in the United States, or as provided by section 363 of this title, which is filed by an inventor or inventors named in the previously filed application shall have the same effect, as to such invention, as though filed on the date of the prior application, if filed before the patenting or abandonment of or termination of proceedings on the first application or an application similarly entitled to the benefit of the filing date of the first application and if it contains or is amended to contain a specific reference to the earlier filed application.

Please read carefully before signing the Declaration attached to the accompanying Application.

If you have any questions, please contact Morgan & Finnegan, L.L.P.

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